Notice No.2

Rules and Regulations for the Classification of Ships, July 2016

The status of this Rule set is amended as shown and is now to be read in conjunction with this and prior Notices. Any corrigenda included in the Notice are effective immediately.

Please note that paragraphs, Tables and Figures are not shown in their entirety. This Corrigenda Notice shows amendments only.

Issue date: November 2016

Amendments to	Effective date
Part 1, Chapter 2, Section 2	Corrigenda
Part 1, Chapter 3, Section 21	Corrigendum
Part 3, Chapter 2, Sections 1 & 3	Corrigenda
Part 3, Chapter 3, Section 5	Corrigenda
Part 3, Chapter 4, Sections 3, 5, 6 & 7	Corrigenda
Part 3, Chapter 5, Sections 1, 2 & 4	Corrigenda
Part 3, Chapter 6, Sections 2, 4 & 7	Corrigenda
Part 3, Chapter 7, Sections 3 & 6	Corrigenda
Part 3, Chapter 9, Sections 3, 4 & 5	Corrigenda
Part 3, Chapter 10, Sections 2, 4 & 5	Corrigenda
Part 3, Chapter 11, Sections 4 & 8	Corrigenda
Part 3, Chapter 13, Sections 1, 2, 3, 6, 7, 8, 9 & 10	Corrigenda
Part 3, Chapter 14, Section 9	Corrigenda
Part 3, Chapter 16, Sections 3, 5, 6, 8, 10, 11 & 12	Corrigenda
Part 4, Chapter 1, Sections 3, 4 & 6	Corrigenda
Part 4, Chapter 2, Sections 2, 3, 6, 8 & 9	Corrigenda
Part 4, Chapter 3, Section 7	Corrigenda
Part 4, Chapter 4, Sections 3 & 4	Corrigenda
Part 4, Chapter 5, Section 2	Corrigenda
Part 4, Chapter 7, Sections 3, 8, 10 & 12	Corrigenda
Part 4, Chapter 8, Sections 2, 3, 7, 12, 14 & 15	Corrigenda
Part 4, Chapter 9, Sections 4, 8 & 9	Corrigenda
Part 4, Chapter 10, Sections 2, 3 & 4	Corrigenda
Part 4, Chapter 12, Sections 1, 2, 4 & 17	Corrigenda
Part 5, Chapter 1, Section 3	Corrigendum
Part 5, Chapter 2, Sections 1, 2, 7 & 12	Corrigenda
Part 5, Chapter 12, Section 5	Corrigenda
Part 5, Chapter 13, Sections 2, 6 & 12	Corrigenda
Part 5, Chapter 14, Sections 4 & 8	Corrigenda

Lloyd's
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Part 5, Chapter 19, Section 1	Corrigendum
Part 5, Chapter 24, Section 7	Corrigenda
Part 6, Chapter 1, Section 1	Corrigendum
Part 6, Chapter 2, Sections 6 & 14	Corrigenda
Part 6, Chapter 3, Section 4	Corrigenda
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Part 7, Chapter 12, Section 1	Corrigenda
Part 8, Chapter 2, Section 12	Corrigendum

Part 1, Chapter 2
Classification Regulations

■ *Section 2*
Character of classification and class notations

2.3 Class notations (hull)

2.3.17 **ShipRight ( ).** Where one or more of LR's ShipRight procedures for the following have been satisfactorily applied, then a notation showing the associated characters of the procedure(s) within brackets will, at the Owner's request, be entered in column 4 of the *Register Book*, preceded by the word **ShipRight**, e.g. **ShipRight(CM, SDA, FDA plus(25,NA))**. The requirements pertaining to these notations and the ShipRight procedures are given in *Pt 3, Ch 16 ShipRight Procedures for the Design, Construction and Lifetime Care of Ships*.

SDA This ShipRight notation (Structural Design Assessment) will be assigned when direct calculations in accordance with the relevant ShipRight procedures have been applied. The ShipRight notation **SDA** is mandatory upon application of any of the following ShipRight notations: **FDA, FDA plus(), FDA ICE, FDA SPR** ~~and **WDA**~~, **WDA1** and **WDA2**.

WDA1 This ShipRight notation (Whipping Design Assessment Level 1) will be assigned when an appraisal has been made of the ~~vibrational~~ dynamic response of the hull structure due to wave impact loads (Whipping) in accordance with the relevant ShipRight procedures.

WDA2 This ShipRight notation (Whipping Design Assessment Level 2) will be assigned when an appraisal has been made of the ~~vibrational~~ dynamic response of the hull structure due to wave impact loads (Whipping) in accordance with the relevant ShipRight procedures.

2.5 Class notations (machinery special features)

2.5.2 The following class notations are associated with positional mooring systems, or thruster-assisted positional mooring systems, and may be assigned as considered appropriate by the Classification Committee:

PM Assigned when a positional mooring system is fitted. ~~It is not intended to apply to vessels which have station-keeping capabilities, but which are not required to remain on station in adverse weather conditions.~~ This notation can be supplemented by a Thrust-Assisted notation **(T1)** [or **(T2)** or **(T3)**].

PMC Assigned when a positional mooring system for mooring in close proximity to other vessels or installations is fitted. ~~It is not intended to apply to vessels which have station-keeping capabilities, but which are not required to remain on station in adverse weather conditions.~~ This notation can be supplemented by a Thrust-Assisted notation **(T1)** [or **(T2)** or **(T3)**].

Note This notation is not intended to apply to vessels where station-keeping capabilities may be suspended for short periods during adverse weather conditions and a subsequent loss of position allowed.

Part 1, Chapter 3
Periodical Survey Regulations

■ *Section 21*
Controlled atmosphere systems

21.1 Retention of class

21.1.1 It is a prerequisite of the **CA** notation that the refrigeration installation on board already conforms to a ✠ **Lloyd's RMC** class notation. ~~*see*~~ *See Pt 1, Ch 2, 2.6 Class notations (refrigerated cargo installations (RMC), controlled atmosphere (CA) systems and carriage of refrigerated containers (CRC)) 2.6.1*.

Part 3, Chapter 2
Materials

■ *Section 1*
Materials of construction

1.2 Steel

1.2.1 Steel having a specified minimum yield stress of 235 N/mm^2 ~~(24 kgf/mm^2)~~ is regarded as mild steel. Steel having a higher specified minimum yield stress is regarded as higher tensile steel.

Table 2.1.1 Values of K_L

Specified minimum yield stress in N/mm^2 ~~(kgf/mm^2)~~	k_L
235 ~~(24)~~	1,0
265 ~~(27)~~	0,92
315 ~~(32)~~	0,78
355 ~~(36)~~	0,72
390 (40)	0,68 (0,66 *see* Note 3)
460 ~~(47)~~ *see* Note 3	0,62 *see* Note 3

1.2.3 The local scantling requirements of higher tensile steel plating, longitudinals, stiffeners and girders may be based on a *k* factor determined as follows:

$$\cancel{k = \frac{235}{\sigma_o}\left(k=\frac{24}{\sigma_o}\right)} \quad k = \frac{235}{\sigma_o}$$

or 0,66, whichever is the greater,

where

σ_o = specific minimum yield stress in N/mm^2 ~~(kgf/mm^2)~~

1.2.4 For the application of the requirements of *Pt 3, Ch 2, 1.2 Steel 1.2.2* and *Pt 3, Ch 2, 1.2 Steel 1.2.3*, special consideration will be given to steel where σ_o >355 N/mm^2 ~~(36 kgf/mm^2)~~. Where such steel grades are used in areas which are subject to fatigue loading, the structural details are to be verified using fatigue design assessment methods.

1.2.5 For container ships only, a k_L factor of 0,66 may be applied to steel with a specified minimum yield stress of 390 N/mm^2 ~~(40 kgf/mm^2)~~, or a k_L factor of 0,62 may be applied to steel with a specified minimum yield stress of 460 N/mm^2 ~~(47 kgf/mm^2)~~ for structural members that contribute to the ship's longitudinal strength, provided that:

■ *Section 3*
Corrosion protection

3.4 Aluminium and magnesium anodes

3.4.1 Aluminium and aluminium alloy anodes are permitted in tanks used for the carriage of oil, but only at locations where the potential energy does not exceed 275 J ~~(28 kgf m)~~. The weight of the anode is to be taken as the weight at the time of fitting, including any inserts and fitting devices.

■ *Section 5*
Design loading

5.1 General

Table 3.5.1 Design heads and permissible cargo loadings

Structural item and position	Component	Standard stowage rate C, in m^3/tonne	Design loading p, in kN/m^2	Equivalent design head h_i in meters	Permissible cargo loading in kN/m^2	Equivalent permissible head, in metres
Design heads and permissible cargo loadings (metric units)						
Weather deck (general cargo)				h_1		
(a) Loading for minimum scantlings						
Forward of 0,075L from F.P.	Beams and longitudinals	1,39	1,296	1,8	0,865	1,2
	Primary structure		3,02 + 1,467E	4,2 + 2,04E		
Between 0,12L and 0,075L from F.P.	Beams and longitudinals	1,39	1,08	1,5	0,865	1,2
	Primary structure		2,30 + 1,467E	3,2 + 2,04E		
Aft of 0,12L from F.P.	Beams and longitudinals	1,39	0,865 + 1,467E	1,2 + 2,04E	0,865	1,2
	Primary structure					
(b) Specified cargo loading						
Forward of 0,075L from F.P.	Beams and longitudinals	1,39	$2{,}5p_a + 1{,}467E$ or as (a), whichever is larger (Note 1)	$3{,}5p_a + 2{,}04E$ (Note 1)	p_a	$1{,}39p_a$
	Primary structure		$3{,}5p_a + 1{,}467E$ or as (a), whichever is larger (Note 1)	$4{,}87p_a + 2{,}04E$ (Note 1)		
Between 0,12L and 0,075L from F.P.	Beams and longitudinals	1,39	$2{,}0p_a + 1{,}467E$ or as (a), whichever is larger (Note 1)	$2{,}78p_a + 2{,}04E$ (Note 1)	p_a	$1{,}39p_a$
	Primary structure		$2{,}67p_a + 1{,}467E$ or as (a), whichever is larger (Note 1)	$3{,}71p_a + 2{,}04E$ (Note 1)		
Aft of 0,12L from F.P	Beams and longitudinals	1,39	$p_a + 1{,}467E$ (Note 1)	$1{,}39p_a + 2{,}04E$ (Note 1)	p_a	$1{,}39p_a$
	Primary structure		$p_a + 1{,}467E$ (Note 1)	$1{,}39p_a + 2{,}04E$ (Note 1)		
Cargo decks				h_2		
General cargo (standard loads)	All structure	1,39	$\frac{H_{td}}{1{,}39}$	H_{td}	$\frac{H_{td}}{1{,}39}$	H_{td}
Special cargo (specified loads)		C	p_a	Cp_a	p_a	Cp_a
Machinery space,		1,39	1,87	2,6	—	—

workshop and stores						
Ships store		1,39	1,44	2,0	—	—
Accomodation decks (clear of tanks)	All structure	1,39	0,865	h_3 1,2	—	—
Superstructure decks (Note 2)				h_3		
1st tier	Beams and longitudinals	—	—	0,9 Where the deck is exposed to the weather, add 2,04*E*	—	—
2nd tier				0,6		
3rd tier and above				0,45		
Decks forming crown of tunnels and deep tanks	Plating and stationers	*C*	$\frac{h}{C}$	h_4	—	—
				h		
			where *h* = ½ height of stand pipe above crown			
(c) Bulk carrier (*see Pt 3, Ch 3, 1.1 Application 1.1.3*) with topside tanks						
Weather deck outside line of hatchways in way of cargo hold region, when topside tanks empty	Beams and longitudinals	1,39	–	–	$\frac{h_{td}}{1,39}$	*h* = the lesser of (i) 0,22*B* (ii) $1,2+0,39\,\frac{W_b}{A}$ where W_b = weight of water ballast in the topside tank per frame space, in tonne-f *A* = Corresponding areat, (m^2), of deck in way over one hold frame space
	Primary Structure	1, 39	–	–		
Cargo hatch covers (standard loading)				h_H		
Steel cover	Webs, stiffeners and plating	1,39	$\frac{H_{td}}{1,39}$	H_{td}	$\frac{H_{td}}{1,39}$	H_{td}
Wood cover	—	1,39	—	—	$\frac{H_{td}}{1,39}$	H_{td}
Inner bottom				*H*		
Ship without heavy cargo notation	Plating and stiffeners	1,39	—	—	*T*	1,39*T*
Ship with heavy cargo notation		*C* but ≤ 0,865	$\frac{H}{C}$	*H*	$\frac{H}{C}$	*H*
Watertight bulkheads	Plating and stiffeners	0,975	$\frac{h_4}{0,975}$	h_4 from Fig. 3.5.2	–	–
Deep tank bulkhead	Plating and stiffeners	*C* but ≤ 0,975	$\frac{h_4}{C}$	h_4 from Fig. 3.5.2	–	–

5.2 Symbols

5.2.1 The symbols used in this Section are defined as follows:
L, L_{pp}, C_b, *B*, *D* and *T* as defined in *Pt 3, Ch 1, 6.1 Principal particulars*

p = design loading, in kN/m^2 ~~(tonne-f/m^2)~~

p_a = applied loading, in kN/m^2 ~~(tonne-f/m^2)~~

Part 3, Chapter 4
Longitudinal Strength

■ *Section 3*
Application

3.3 Exceptions

3.3.1 Individual consideration based on direct calculation procedures will generally be required for ships having one or more of the following characteristics:

- Large deck openings, or where warping stresses in excess of 14,7 N/mm^2 ~~(1,5 kgf/mm^2)~~ are likely to occur.

■ *Section 5*
Hull bending strength

5.1 Symbols

5.1.1 The symbols used in this Section are defined as follows:

M_s = design still water bending moment, sagging (negative) and hogging (positive), in kN m ~~(tonne-f m)~~, to be taken negative or positive according to the convention given in *Pt 3, Ch 4, 5.3 Design still water bending moments 5.3.2*

$\bar{M}_s$ = maximum permissible still water bending moment, sagging (negative) and hogging (positive), in kN m ~~(tonne-f m)~~, *see Pt 3, Ch 4, 5.4 Minimum hull section modulus*

M_w = design hull vertical wave bending moment, sagging (negative) and hogging (positive), in kN m ~~(tonne-f m)~~, to be taken negative or positive according to the convention given in *Pt 3, Ch 4, 5.3 Design still water bending moments 5.3.2*

σ = permissible combined stress (still water plus wave), in N/mm^2 ~~(kgf/mm^2)~~, *see Pt 3, Ch 4, 5.5 Permissible still water bending moments*

σ_D, σ_B = maximum hull vertical bending stress at strength deck and keel respectively, in N/mm^2 ~~(kgf/mm^2)~~

5.5 Permissible still water bending moments

5.5.1 The permissible still water bending moments sagging and hogging are to be taken as the lesser of the following:

(a) $|\bar{M}|_s = F_D \sigma Z_D \times 10^3 - |M_w|$ kN m ~~(tonne-f m)~~

(b) $|\bar{M}|_s = F_B \sigma Z_B \times 10^3 - |M_w|$ kN m ~~(tonne-f m)~~

where

σ = the permissible combined stress in N/mm^2 ~~(kgf/mm^2)~~ is given in *Pt 3, Ch 4, 5.6 Permissible hull vertical bending stresses* and F_D and F_B are defined in *Pt 3, Ch 4, 5.7 Local reduction factors 5.7.2*. M_w is the design wave bending moment, sagging or hogging as appropriate, in accordance with *Pt 3, Ch 4, 5.2 Design vertical wave bending moments*.

5.6 Permissible hull vertical bending stresses

5.6.1 The permissible combined (still water plus wave) stress for hull vertical bending, σ, is given by:

(a) ~~Within~~ within 0,4*L* amidships

$$\cancel{\sigma = \frac{175}{k_L}\ \mathrm{N/mm^2}\left(\frac{17{,}84}{k_L}\ \mathrm{kgf/mm^2}\right)} \qquad \sigma = \frac{175}{k_L}\ \mathrm{N/mm^2}$$

(b) for continuous longitudinal structural members outside 0,4*L* amidships

$$\sigma = \left(75 + 543\frac{d}{L} - 699\left(\frac{d}{L}\right)^2\right)\frac{1}{k_L}\ \mathrm{N/mm^2}$$

$$\cancel{\left(\sigma = \left(75 + 543\frac{d}{L} - 699\left(\frac{d}{L}\right)^2\right)\frac{0{,}102}{k_L}\ \mathrm{kgf/mm^2}\right)}$$

where *d* is the distance, in metres, from the F.P. (for the fore end region) or from the A.P. (for the aft end region), as appropriate, to the location under consideration.

Special consideration will be given to increasing the permissible stress outside 0,4*L* amidships to

$$\cancel{\frac{175}{k_L}\ \mathrm{N/mm^2}\left(\frac{17{,}84}{k_L}\ \mathrm{kgf/mm^2}\right)} \qquad \frac{175}{k_L}\ \mathrm{N/mm^2}$$

provided that sufficient buckling checks are carried out.

5.7 Local reduction factors

5.7.1 The maximum hull vertical bending stresses at deck, σ_D, and keel, σ_B, are given by the following, using the appropriate combination of bending moments to give sagging and hogging stresses:

~~$\sigma_D = \frac{|\bar{M}_s + M_w|}{Z_D} \times 10^{-3}$ N/mm^2 (kgf/mm^2)~~ $\sigma_D = \frac{|\bar{M}_s + M_w|}{Z_D} \times 10^{-3}$ N/mm^2

~~$\sigma_B = \frac{|\bar{M}_s + M_w|}{Z_B} \times 10^{-3}$ N/mm^2 (kgf/mm^2)~~ $\sigma_B = \frac{|\bar{M}_s + M_w|}{Z_B} \times 10^{-3}$ N/mm^2

Where the ship is always in the hogging condition, the sagging bending moment is to be specially considered.

5.9 Continuous strength members above strength deck

5.9.1 Where trunk decks or continuous hatch coamings are effectively supported or deck longitudinals or girders are fitted above the strength deck, the modulus Z_c is to be not less than Z_{min}. The scantling reduction factor, F_D, referred to strength deck at side, is applicable and, in addition to the requirement given in *Pt 3, Ch 4, 5.5 Permissible still water bending moments 5.5.1*, the permissible still water bending moments, sagging and hogging, are not to exceed:

$|\bar{M}|_s$ $= \sigma Z_c \times 10^3 - |M_w|$ kN m ~~(tonne-f m)~~

■ *Section 6*
Hull shear strength

6.1 Symbols

6.1.1 The symbols used in this Section are defined as follows:

$\boldsymbol{Q_s}$ = design hull still water shear force, in kN ~~(tonne-f)~~, to be taken as negative or positive according to the convention given in *Pt 3, Ch 4, 6.4 Design still water shear force 6.4.2*

$\boldsymbol{\bar{Q}_s}$ = permissible hull still water shear force, in kN ~~(tonne-f)~~, *see Pt 3, Ch 4, 6.5 Permissible still water shear force*

Q_w = design hull wave shear force, in kN ~~(tonne-f)~~, to be taken as negative or positive according to the convention given in *Pt 3, Ch 4, 6.4 Design still water shear force 6.4.2*

τ = permissible combined shear stress (still water plus wave), in N/mm^2 ~~(kgf/mm^2)~~, *see Pt 3, Ch 4, 6.6 Permissible shear stress*

τ_A = design shear stress, in N/mm^2 ~~(kgf/mm^2)~~, as given in *Pt 3, Ch 4, 6.7 Design shear stress 6.7.1* for use in *Pt 3, Ch 4, 7.4 Design stress*.

6.3 Design wave shear force

6.3.1 The design hull wave shear force, Q_w, at any position along the ship is given by:

$Q_w = K_1 K_2 Q_{WO}$kN ~~(tonne – f)~~

where

$\boldsymbol{Q_{wo}}$ = 0,3$C_1 LB$ (C_B + 0,7) kN

~~(0,0306C_1 LB (C_B + 0,7) tonne-f)~~

and C_B is to be taken not less than 0,6

K_1 is to be taken as follows, *see also Figure 4.6.1 Shear force factor K_1*:

6.4 Design still water shear force

6.4.4 If the hull shear forces in kN ~~(tonne-f)~~ at transverse bulkheads A and B are calculated to be Q_A and Q_B respectively (with appropriate algebraic signs), the excess load or buoyancy over hold AB is given by $Q_B — Q_A$ and the load transmitted to each bulkhead is:

(a) 0,5F ($Q_B — Q_A$) kN ~~(tonne-f)~~

where F is the bulkhead factor as given in *Pt 3, Ch 4, 6.4 Design still water shear force 6.4.3*.

See Figure 4.6.2 Shear force correction.

6.4.5 The corrected shear forces, Q_A' and Q_B', at bulkheads A and B with respect to hold AB are then obtained from:

$\boldsymbol{Q_A'}$ = Q_A + 0,5F ($Q_B — Q_A$) kN ~~(tonne-f)~~

$\boldsymbol{Q_B'}$ = Q_B — 0,5F ($Q_B — Q_A$) kN ~~(tonne-f)~~

6.5 Permissible still water shear force

6.5.1 The permissible hull still water shear force is given by the minimum value obtained from:

$$|Q_s| = \tau \frac{I\delta_i}{100 A_{z[d1]}} - |Q_w| \text{ kN} \cancel{\text{(tonne – f)}}$$

6.5.2 The permissible shear forces assigned for approved loading instruments will normally be based on P*t 3, Ch 4, 6.5 Permissible still water shear force 6.5.1*. However, where use is made of an approved loading instrument incorporating a facility to calculate the transverse distribution of shear forces, separate permissible still water shear forces, Q_{si} may be assigned for the structural members indicated in *Table 4.6.1 f_i factors* for the hull configuration under consideration.

$|Q_{si}| = (f_i + m_i)|Q_s|$ kN ~~(tonne-f)~~

6.6 Permissible shear stress

6.6.1 The permissible combined shear stress (still water plus wave) is to be taken as:

$$\cancel{\tau = \frac{110}{k_L}\,\text{N/mm}^2\left(\frac{11{,}2}{k_L}\,\text{kgf/mm}^2\right)}$$

$$\tau = \frac{110}{k_L}\,\text{N/mm}^2$$

6.7 Design shear stress

6.7.1 The design shear stress for use in *Pt 3, Ch 4, 7.4 Design stress* is to be taken as:

$$\tau_A = 100Az\frac{|Q_s| + |Q_w|}{I\delta_i}\ \text{N/mm}^2$$

$$\cancel{\left(10{,}2Az\frac{|Q_s| + |Q_w|}{I\delta_i}\,\text{kgf/mm}^2\right)}$$

■ *Section 7*
Hull buckling strength

7.2 Symbols

7.2.1 The symbols used in this Section are defined as follows:

E = modulus of elasticity, in N/mm^2 ~~(kgf/mm^2)~~

= 206000 N/mm^2~~(21000 kgf/mm^2)~~ for steel

σ_o = specified minimum yield stress, in N/mm^2 ~~(kgf/mm^2)~~

σ_A = design longitudinal compressive stress in N/mm^2 ~~(kgf/mm^2)~~

σ_{CRB} = critical buckling stress in compression, in N/mm^2 ~~(kgf/mm^2)~~ corrected for yielding effects

σ_E = elastic critical buckling stress in compression, in N/mm^2~~(kgf/mm^2)~~

τ_A = design shear stress in N/mm^2 ~~(kgf/mm^2)~~

τ_{CRB} = critical buckling stress in shear, N/mm^2 ~~(kgf/mm^2)~~ corrected for yielding effects

τ_E = elastic critical buckling stress in shear, in N/mm^2 ~~(kgf/mm^2)~~

7.4 Design stress

7.4.1 Design longitudinal compressive stress, σ_A, is to be determined in accordance with *Pt 3, Ch 4, 5 Hull bending strength*:

minimum σ_A = $\cancel{\frac{30}{k_L}\,\text{N/mm}^2\left(\frac{3{,}06}{k_L}\,\text{kgf/mm}^2\right)}$ minimum σ_A = $\frac{30}{k_L}\,\text{N/mm}^2$

Table 4.7.2 Elastic critical buckling strength of plating

Mode	Elastic critical buckling stress, N/mm^2 ~~(kgf/mm^2)~~
Note Where the elastic critical buckling stress, as evaluated from (a), (b) or (c), exceeds 50 per cent of specified minimum yield stress of the material, the corrected critical buckling stresses in compression (σ_{CRB}) and shear (τ_{CRB}) are given by:	
$\sigma_{CRB} = \sigma_E$ when $\sigma_E \le \frac{\sigma_o}{2}$ $= \sigma_o\left(1 - \frac{\sigma_o}{4\sigma_E}\right)$ when $\sigma_E > \frac{\sigma_o}{2}$	N/mm^2 ~~(kgf/mm^2)~~
$\tau_{CRB} = \tau_E$ when $\tau_E \le \frac{\tau_o}{2}$ $= \tau_o\left(1 - \frac{\tau_o}{4\tau_E}\right)$ when $\tau_E > \frac{\tau_o}{2}$	N/mm^2 ~~(kgf/mm^2)~~

7.4.2 Design shear stress, τ_A, is to be determined in accordance with *Pt 3, Ch 4, 6 Hull shear strength*. For initial design purposes, τ_A may be taken as:

$$\tau_A = \cancel{\frac{110}{k_L}\ \text{N/mm}^2 \left(\frac{11{,}2}{k_L}\ \text{kgf/mm}^2\right)} \qquad \tau_A = \frac{110}{k_L}\ \text{N/mm}^2$$

7.5 Scantling criteria

Table 4.7.3 Elastic critical buckling strength of longitudinals

Mode	Elastic critical buckling stress, N/mm^2 ~~(kgf/mm^2)~~
Note *1.* Where the elastic critical buckling stress, as evaluated from (a), (b) or (c), exceeds 50 per cent of specified minimum yield stress of the material, the corrected critical buckling stress in compression (σ_{CRB}) is given by: $\sigma_{CRB} = \sigma_o \left(1 - \frac{\sigma_o}{4\sigma_E}\right)$ N/mm^2 ~~(kgf/mm^2)~~	

Part 3, Chapter 5
Fore End Structure

■ *Section 1*
General

1.6 Strengthening against bow flare slamming

Table 5.1.1 Additional ~~strengthing~~ strengthening of bottom forward

Item	Requirements
Symbols	
$p = 9{,}81\, h_s s c_1 \left[S - \frac{s}{2000}\right] \times 10^{-3}$ kN $\cancel{= \left(h_s s c_1 \left[S - \frac{s}{2000}\right] \times 10^{-3}\ \text{tonne} - \text{f}\right)}$ $\overline{\sigma}$ = permissible direct stress, in N/mm^2 ~~(kgf/mm^2),~~ given in *Table 5.1.2 Permissible stresses* $\overline{\tau}$ = permissible shear stress, in N/mm^2 ~~(kgf/mm^2),~~ given in *Table 5.1.2 Permissible stresses*	

Table 5.1.2 Permissible stresses

Item		Direct stress, $\overline{\sigma}$ In N/mm^2 ~~(kgf/mm^2)~~ *see* Note	Shear stress, $\overline{\tau}$ In N/mm^2 ~~(kgf/mm^2)~~
Primary member web stiffener on area A_f	(a) Flat bars *see* Note	$\frac{10{,}3}{k}\left[33 - \frac{d}{t\sqrt{k}}\right]$ $\cancel{\left(\frac{10{,}5}{k}\left[33 - \frac{d}{t\sqrt{k}}\right]\right)}$	– –
	(b) Bulb plates *see* Note	$\frac{8{,}6}{k}\left[40 - \frac{d}{\left(\frac{100A_f}{d} - \frac{t}{6}\right)\sqrt{k}}\right]$	– –

		$\cancel{\left(\frac{0,88}{\text{k}}\left[40-\frac{d}{\left(\frac{100A_{\text{f}}}{d}-\frac{t}{6}\right)\sqrt{k}}\right]\right)}$	
	(c) Inverted angles	$\frac{220}{k}\cancel{\left(\frac{22,4}{k}\right)}$	–
Primary member web stiffener on area A_{fc}		$\frac{245}{k}\cancel{\left(\frac{25}{k}\right)}$	–
Primary member web stiffener lapped to secondary member on area A_{L}		–	$\frac{167}{k}\cancel{\left(\frac{17}{k}\right)}$
Lug or web connection on area A_1	Single	–	$\frac{124}{k}\cancel{\left(\frac{12,6}{k}\right)}$
	Double	–	$\frac{141}{k}\cancel{\left(\frac{14,4}{k}\right)}$
Note $\bar{\sigma}$ to be taken not greater than $\frac{220}{k}\cancel{\left(\frac{22,4}{k}\right)}$			

Table 5.1.3 Buckling procedure for primary member web plating and web stiffener

Symbols
E = modulus of elasticity, in N/mm^2 ~~(kgf/mm^2)~~
= 206000 N/mm^2 ~~(21000 kgf/mm^2)~~ for steel
P = total load transmitted to the connection
= 10,06 S_{CM} s_{CM} h_S x 10 $^{-3}$ kN
~~(P = 1,025 S_{CM} s_{CM} h_S x 10 $^{-3}$ tonne-f)~~
P_w = load transmitted through the primary member web stiffener, in kN ~~(tonne-f)~~
σ_0 specified minimum yield stress, in N/mm^2~~(kgf/mm^2)~~

■ *Section 2*
Deck structure

2.3 Deck stiffening

Table 5.2.2 Lower deck plating forward

Note 1. Where the deck loading exceeds 43,2 kN/m^2 ~~(4,4 tonne-f/m^2)~~, the thickness of plating will be specially considered. This is equivalent to a 'tween deck height of 6,1 m in association with the standard stowage rate 1,39 m^3/tonne.

2.5 Deck openings

Table 5.2.3 Strength/weather deck longitundals forward

Note 2. Where weather decks are intended to carry deck cargo and the loading is in excess of 8,5 kN/m^2 ~~(0,865 tonne-f/m^2)~~, the scantlings of longitudinals may be required to be increased to comply with the requirements for location (1) in *Table 1.4.4 Cargo and accommodation deck longitudinals* using the equivalent design head, for specified cargo loadings, for weather decks given in *Table 3.5.1 Design heads and permissible cargo loadings*.

Table 5.2.4 Weather deck beams forward

Note 2. Where weather decks are intended to carry deck cargo and the loading is in excess of 8,5 kN/m^2 ~~(0,865 tonne-f/m^2)~~, the scantlings of beams are also to comply with the requirements for location (2) in *Table 1.4.5 Strength/weather, cargo and accommodation deck beams* using the equivalent design head, for specified cargo loadings, for weather decks given in *Table 3.5.1 Design heads and permissible cargo loadings*.

■ *Section 4*
Shell envelope framing

4.5 Primary structure at sides

Table 5.4.4 Primary structure forward

Item and location	Modulus, in cm^3	Inertia, in cm^4
(6) Web frames supporting side stringers forward of 0,2*L* from the F.P, *see* Notes 1, 2 and 3	Z to be determined from the calculations based on the following assumptions: (a) Fixed ends (b) Point loadings from stringers (c) Head γh_4 or γh_{T1} as applicable (d) Bending stress $\frac{93,2}{k}\ \text{N/mm}^2 \cancel{\left(\frac{9,5}{k}\ \text{kgf/mm}^2\right)}$ (e) Shear stress $\frac{83,4}{k}\ \text{N/mm}^2 \cancel{\left(\frac{8,5}{k}\ \text{kgf/mm}^2\right)}$	In deep tanks $I = \frac{2,5}{k} l_e Z$

Part 3, Chapter 6
Aft End Structure

■ *Section 2*
Deck structure

2.3 Deck stiffening

Table 6.2.2 Lower deck plating aft

Note Where the deck loading exceeds 43,2 kN/m^2, ~~(4,4 tonne-f/m^2)~~, the thickness of plating will be specially considered. This is equivalent to a 'tween deck height of 6,1 m in association with the standard stowage rate of 1,39 m^3/tonne.

Table 6.2.3 Strength/weather deck longitudinals aft

Note 2. Where weather decks are intended to carry deck cargo and the loading is in excess of 8,5 kN/m^2 ~~(0,865 tonne-f/m^2)~~ the scantlings of longitudinals are also to comply with the requirements for location (1) in *Table 1.4.4 Cargo and accommodation deck longitudinals* using the equivalent design head, for specified cargo loadings, for weather decks given in *Table 3.5.1 Design heads and permissible cargo loadings*.

■ *Section 4*
Shell envelope framing

4.5 Primary structure at sides

Table 6.4.4 Primary structure aft

Item and location	Modulus, in cm^3	Inertia, in cm^4
(6) Web frames supporting side stringers in after peak, *see* Note 3	*Z* ~~=~~ is to be determined from the calculations based on the following assumptions: (a) Fixed ends (b) Point loadings from stringers (c) Head h_4 or h_{T1} as applicable (d) Bending stress $\frac{93,2}{k}\ \text{N/mm}^2 \cancel{\left(\frac{9,5}{k}\ \text{kgf/mm}^2\right)}$ (e) Shear stress $\frac{83,4}{k}\ \text{N/mm}^2 \cancel{\left(\frac{8,5}{k}\ \text{kgf/mm}^2\right)}$	In deep tanks $I = \frac{2,5}{k} l_e Z$

■ *Section 7*
Sternframes and appendages

7.2 Sternframes

Table 6.7.2 Permissible stresses for sole pieces

Mode	Permissible stress
(1) Equivalent stress	115/K$_0$ N/mm^2 ~~(11,7K$_0$ kgf/mm^2)~~

7.3 Rudder horns

Table 6.7.3 Permissible stresses for rudder horns

Mode	Permissible stress	
(1) Shear stress	48/K$_o$ N/mm^2	~~(4,9/K$_o$ kgf/mm^2)~~
(2) Equivalent stress	120/K$_o$ N/mm^2	~~(12/K$_o$ kgf/mm^2)~~
Symbols		
σ_e = equivalent stress = ~~$\sqrt{\sigma_{b2} + 3\left(\tau^2 + \tau_{t2}\right)}$ N/mm^2 (kgf/mm^2)~~ $\sqrt{\sigma_b^2 + 3\left(\tau^2 + \tau_t^2\right)}$ N/mm^2		

Part 3, Chapter 7
Machinery Spaces

■ *Section 3*
Side shell structure

3.3 Primary structure – Longitudinal framing

Table 7.3.1 Primary structure in machinery spaces

Scantlings	
Section modulus, in cm^3	Min. web depth d_w, in mm
$Z = 1{,}68CkTSl_e\sqrt{D}$ $Z = 7{,}75kShl_e^2$ Determined from calculation based on following assumptions: (a) Fixed ends (b) Point loadings (c) Head to upper deck at side (d) Bending stress 93,2 N/mm^2 ~~(9,5 kgf/mm^2)~~ (e) Shear stress 83,4 N/mm^2 ~~(8,5 kgf/mm^2)~~	2,5 x depth of adjacent main frames

■ *Section 6*
Engine seatings

6.2 Seats for engines

Table 7.6.1 Seats for engines – Recommended scantlings

Scantlings of one seat
$A = (120 + 44{,}2f + 4{,}07f^2)$cm^2 ~~($A = (120 + 32{,}5f + 2{,}2f^2)$cm^2)~~ Minimum thickness: (a) Where two girders fitted $t = (19 + 3{,}4f)$ mm ~~($t = (19 + 2{,}5f)$ mm)~~ (b) Where one girder fitted $t = (25 + 3{,}4f)$ mm ~~($t = (25 + 2{,}5f)$ mm)~~

Number: Generally two but a single girder can be accepted where all the following apply: (a) $f < 1{,}84$ ~~(2,5)~~ (b) $P < 5900$ kW ~~(8000 bhp)~~ (c) $L < 100$ m
Total thickness: (a) Where two girders are fitted $t_1 + t_2 = (28 + 4{,}08f)$ mm ~~($t_1 + t_2 = (28 + 3{,}0f)$ mm)~~ (b) Where one girder is fitted $t_1 = (15 + 4{,}08f)$ mm ~~($t_1 = (15 + 3{,}0f)$ mm)~~
Thickness: $t_3 = (10 + 1{,}5f)$ mm ~~($t_3 = (10 + 1{,}1f)$ mm)~~

Part 3, Chapter 9
Special Features

■ *Section 3*
Decks loaded by wheeled vehicles

3.5 Deck longitudinals and beams

3.5.1 The section modulus, *Z*, of deck beams or longitudinals is to be not less than that required for a weather or cargo deck as appropriate, nor less than the following:

(c) For decks designed for the carriage of wheeled vehicles only that required to satisfy the most severe arrangement of print wheel loads on the stiffener in association with a bending stress of $\cancel{\frac{100}{k}\ \mathrm{N/mm^2}\left(\frac{10{,}2}{k}\ \mathrm{kgf/mm^2}\right)}$ $\frac{100}{k}\ \mathrm{N/mm^2}$ assuming 100 per cent end fixity.

3.6 Deck girders and transverses

3.6.2 Where the member supports point loads, with or without the addition of uniformly distributed load, the section modulus is to be based on a stress of $\cancel{\frac{123{,}6}{k}\ \mathrm{N/mm^2}\left(\frac{12{,}6}{k}\ \mathrm{kgf/mm^2}\right)}$ $\frac{123{,}6}{k}\ \mathrm{N/mm^2}$, assuming 100 per cent end fixity.

■ *Section 4*
Moveable decks

4.5 Pontoon deck plating

4.5.3 Where it is proposed to use plywood decking, the arrangement and thickness will be considered. Plywood alone, is not, generally, to be used for axle loads in excess of 7,8 kN ~~(0,8 tonne-f)~~.

■ *Section 5*
Helicopter landing decks

5.6 Bimetallic connections

Table 9.5.2 Design load cases for deck stiffening and supporting structure

	Loads
Loadcase	Landing area
	UDL, in kN/m^2 ~~(tonne-f/m^2)~~
(1) Overall distributed loading	2 ~~(0,2)~~

(2) Helicopter emergency landing	0,5 ~~(0,05)~~
(3) Normal usage	0,5 ~~(0,05)~~

Table 9.5.3 Permissible stresses for deck stiffening and supporting structure

Permissible stresses, in N/mm^2 ~~(kgf/mm^2)~~		
Deck secondary structure (beams, longitudinals) (*See* Notes 1 and 2)	Primary structure (transverses, girders, pillars, trusses)	
Bending		Combined bending and axial
$\frac{147}{k}$ $\cancel{\left(\frac{15}{k}\right)}$	$\frac{147}{k}$ $\cancel{\left(\frac{15}{k}\right)}$	0,6σ_c
$\frac{245}{k}$ $\cancel{\left(\frac{25}{k}\right)}$	$\frac{220,5}{k}$ $\cancel{\left(\frac{22,5}{k}\right)}$	0,9σ_c
$\frac{176}{k}$ $\cancel{\left(\frac{18}{k}\right)}$	$\frac{147}{k}$ $\cancel{\left(\frac{15}{k}\right)}$	0,6σ_c

Part 3, Chapter 10
Welding and Structural Details

■ *Section 2*
Welding

2.2 Fillet welds

Table 10.2.1 Weld factors

Note 1. Where pillars are fitted inside tanks or under watertight flats, the end connection is to be such that the tensile stress in the weld does not exceed 108 N/mm^2 ~~(11 kgf/mm^2)~~.

■ *Section 4*
Construction details for primary members

4.5 Web stability

4.5.1 ~~Primary members of asymmetrical section are to be supported by tripping brackets at alternate secondary members. If the section is symmetrical, the tripping brackets may be four spaces apart~~ Primary members are to be supported by tripping brackets. The tripping brackets supporting asymmetrical sections are to be spaced no more than two secondary frames apart. The tripping brackets supporting symmetrical sections are to be spaced no more than four secondary frames apart.

■ *Section 5*
Structural details

5.2 Arrangements at intersections of continuous secondary and primary members

5.2.7 This load is to be apportioned between the connections as follows:

(b) Transmitted through the primary member web stiffener:
$P_2 = P - P_1$ kN~~(tonne – f)~~

Table 10.5.1 Total load transmitted to connection of secondary members

Ship type	Head, h_1, in metres	Total load, *P*, transmitted to connection
(1) Oil tankers, bulk chemical tankers and combination carriers, *see Pt 3, Ch 10, 1.1 Application 1.1.3*	(c) With mid-point of span intermediate between (a) and (b). The value of h_1 is to be obtained by linear interpolation between values from (a) and (b). (d) With mid-point of span higher than 0,6D_2 above base line.	(a) In general $P = 10,06 (S_w - s_1/2) s_1 h_1$ kN ~~($P = 1,025 (S_w - s_1/2) s_1 h_1$ tonne-f)~~ (b) For wash bulkheads $P = 11,77 (S_w - s_1/2) s_1 h_1$ kN ~~($P = 1,2 (S_w - s_1/2) s_1 h_1$ tonne-f)~~
(2) Other ship types for which oil tanker (*see Pt 3, Ch 10, 1.1 Application 1.1.3*) requirements are not applicable	As for (1) except as follows: (b) h_1 for item (1)(d)(ii) above to extend forward of 0,15*L* from the forward perpendicular	$P = 10,06 (S_w - s_1/2) s_1 h_1$kN ~~($P = 1,025 (S_w - s_1/2) s_1 h_1$ tonne-f)~~
(3) Other ship types for which oil tanker (*see Pt 3,Ch 10, 1.1 Application 1.1.3*) requirements are not applicable (continued)	Internal tank boundaries (a) Topside tank longitudinals (b) Inner bottom and hopper longitudinals (iv) For bulk carriers (*see Pt 3, Ch 10, 1.1 Application 1.1.3*) where the topside wing tank is interconnected with hopper side and double bottom tanks h_1 = the distance from the longitudinal under consideration to the top of the topside tank with the ship inclined 25° either way (v) For bulk carriers (*see Pt 3, Ch 10, 1.1 Application 1.1.3*) in way of ballast hold h_1 = the distance from the longitudinal under consideration to the top of the hatchway coaming (c) Longitudinals of inner hull of double hull cargo ships and bulk carriers (*see Pt 3, Ch 10, 1.1 Application 1.1.3*)	$P = 10,06 (S_w - s_1/2) s_1 h_1$kN ~~($P = 1,025 (S_w - s_1/2) s_1 h_1$ tonne-f)~~ $P = 9,81 (S_w - s_1/2) s_1 h_1/C$ kN ~~$P = (S_w - s_1/2) s_1 h_1/C$ tonne-f~~ $P = 10,06 (S_w - s_1/2) s_1 h_1$kN ~~($P = 1,025 (S_w - s_1/2) s_1 h_1$ tonne-f)~~ $P = 10,06 (S_w - s_1/2) s_1 h_1$kN ~~($P = 1,025 (S_w - s_1/2) s_1 h_1$ tonne-f)~~ $P = 10,06 (S_w - s_1/2) s_1 h_1$kN ~~($P = 1,025 (S_w - s_1/2) s_1 h_1$ tonne-f)~~

Table 10.5.3 Permissible stresses

Direct stress, in N/mm^2 ~~(kgf/mm^2)~~ (*see* Notes 1 and 2)		Shear stress, in N/mm^2 ~~(kgf/mm^2)~~ (*see* Note 1)	
Oil tankers	Other ship types for which oil tanker requirements are not applicable	Oil tankers and ship types where primary member stiffener unconnected	Other ship types for which oil tanker requirements are not applicable
147,2 ~~(15,0)~~	157 ~~(16,0)~~	–	–
98,1 ~~(10,0)~~ (double continuous fillet) 147,2 ~~(15,0)~~ (automatic deep penetration)	117,7 ~~(12,0)~~ (double continuous fillet) 157 ~~(16,0)~~ (automatic deep penetration)	– –	– –
–	–	83,4 ~~(8,5)~~ *See* Note 2	98,1 ~~(10,0)~~ *See* Note 2
–	–	68,6 ~~(7,0)~~	98,1 ~~(10,0)~~
–	–	83,4 ~~(8,5)~~	
Note ~~(1)~~ The welding requirements of *Pt 3, Ch 10, 2 Welding*, and where applicable *Pt 3, Ch 10, 5.2 Arrangements at intersections of continuous secondary and primary members 5.2.13* are also to be complied with, *see Pt 3, Ch 10, 1.1 Application 1.1.3*. **Note** ~~(2)~~ Where longitudinals are of higher tensile steel having a yield stress of ~~32 kg/mm^2~~ 315 N/mm^2 or more, these stresses are to be divided by the factor 1,2 for application to side longitudinals above 0,3D_2 from the base-line. For definition of D_2 *see Table 10.5.1 Total load transmitted to connection of secondary members*.			

Part 3, Chapter 11
Closing Arrangements for Shell, Deck and Bulkheads

■ Section 4
Hatch cover securing arrangements and tarpaulins

4.2 Steel covers – Clamped and gasketed

4.2.19 The net sectional area of each securing device is to be not less than:

$$\cancel{A = \frac{1{,}4 S_1 W_1}{50 f} \text{ cm}^2 \left(\frac{1{,}4 S_1 W}{50 f} \text{ cm2}\right)} \qquad A = \frac{1{,}4 S_1 W_1}{50 f} \text{ cm}^2$$

where

f = $\left(\frac{\sigma_c}{235}\right)e$

***W* 1** = the gasket loading per unit length, in N/cm ~~(kgf/cm)~~, but not less than 50 N/cm ~~(5,1 kgf/cm)~~

σc = specified minimum upper yield stress in N/mm^2 ~~(kgf/mm^2)~~ of the steel used for cleats or securing devices, to be taken not greater than 70 per cent of the ultimate tensile strength

e = 0,75 for $\sigma_c \geq 235$ ~~(24)~~

= 1,0 for $\sigma_c < 235$ ~~(24)~~.

4.2.21 In order to ensure compression between gasket and compression bar along the full length, the cover edge stiffness is to be examined. The inertia of the cover edge is to be not less than:
I_E = 0,6$W_1 S_1^4$ cm^4
~~(I_E = 5,89$W_1 S_1^4$ cm^4)~~
where W_1 and S_1 are as defined in *Pt 3, Ch 11, 4.2 Steel covers − Clamped and gasketed 4.2.12*.

■ Section 8
Side and stern doors and other shell openings

8.1 Symbols

8.1.1 The symbols used in this Section are defined as follows:

σ = bending stress, in N/mm^2 ~~(kgf/mm^2)~~

σe = equivalent stress, in N/mm^2 ~~(kgf/mm^2)~~

= $\sqrt{\left(\sigma^2 + 3\,\tau^2\right)}$

σo = minimum yield stress of the bearing material, in N/mm^2 ~~(kgf/mm^2)~~

τ = shear stress, in N/mm^2 ~~(kgf/mm^2)~~.

8.3 Scantlings

8.3.9 The scantlings of such primary members are to be based on direct strength calculations. Normally, formulae for simple beam theory may be applied to determine the bending stress. Members are to be considered to have simply supported end connections. The design load is the uniformly distributed external sea pressure, p_e, as defined in *Pt 3, Ch 11, 8.2 General 8.2.6*. For minimum scantlings, p_e is to be taken as 25 kN/m^2 ~~(2,55 tonne-f/m^2)~~ and the permissible stresses are as follows:

$$\cancel{\tau = \frac{80}{k} \text{ N/mm}^2 \left(\frac{8{,}2}{k} \text{ kgf/mm}^2\right)} \qquad \tau = \frac{80}{k} \text{ N/mm}^2$$

$$\cancel{\sigma = \frac{120}{k} \text{ N/mm}^2 \left(\frac{12{,}2}{k} \text{ kgf/mm}^2\right)} \qquad \sigma = \frac{120}{k} \text{ N/mm}^2$$

$$\cancel{\sigma_e = \frac{150}{k} \text{ N/mm}^2 \left(\frac{15{,}3}{k} \text{ kgf/mm}^2\right)} \qquad \sigma_e = \frac{150}{k} \text{ N/mm}^2$$

8.3.11 The stiffness of the edges of the doors and the hull structure in way are to be sufficient to ensure weathertight integrity. Edge stiffeners/girders are to be adequately stiffened against rotation and are to have a moment of inertia not less than:

$I = 0{,}8 p_1 d^4$ cm^4

~~($I = 8 p_1 d^4$ cm^4)~~

where

p_1 = packing line pressure along edges, not to be taken less than 50 N/cm ~~(5,1 kgf/cm)~~.

8.5 Arrangements for the closing, securing and supporting of doors

8.5.5 Means are to be provided to enable the doors to be mechanically fixed in the open position taking into account the self weight of the door and a minimum wind pressure of 1,5 kN/m^2 ~~(0,153 tonne-f/m^2)~~ acting on the maximum projected area in the open position.

8.6 Design loads

8.6.1 The design force considered for the scantlings of primary members, securing and supporting devices of side shell doors and stern doors are to be taken not less than:

(a) Design forces for securing or supporting devices of doors opening inwards:

External force:

$P_e = Ap_e + P_p$ kN ~~(tonne-f)~~

Internal force:

$P_i = P_o + 10W$ kN

~~($P_i = P_o + 1{,}02W$ tonne-f)~~

(b) Design forces for securing or supporting devices of doors opening outwards:

External force:

$P_e = Ap_e$ kN ~~(tonne-f)~~

Internal force:

$P_i = P_o + 10W + P_p$ kN

~~($P_i = P_o + 1{,}02W + P_p$ tonne-f)~~

(c) Design forces for primary members:

External force:

$P_e = AP_e + 10W$ kN ~~(tonne-f)~~

Internal force:

$P_i = P_o + 10W$ kN

~~($P_i = P_o + 1{,}02W$ tonne-f)~~

whichever is the greater.

The symbols used are defined as follows:

p_e = external sea pressure, in kN/m^2 ~~(tonne-f/m^2)~~, determined at the centre of gravity of the door opening and is not to be taken less than:

= for $Z_G < T$ $10(T-Z_G) + 25$ kN/m^2

~~($1{,}02\,(T - Z_G) + 2{,}55$ tonne – f/m^2)~~

for $Z_G \geq T$ 25 kN/m^2

~~(2,55 tonne – f/m^2)~~

= For stern doors of ships fitted with bow doors, P_e is not to be taken less than:

$P_{emin} = 0{,}6\lambda C_H (0{,}8 + 0{,}6L^{0,5})^2$ kN/m^2

~~($P_{emin} = 0{,}061\lambda C_H (0{,}8 + 0{,}6L^{0,5})^2$ tonne-f/m^2)~~

P_p = total packing force, kN ~~(tonne-f)~~. When packing is fitted, the packing line force per unit length is to be specified, normally not to be taken less than: 5 kN/m ~~(0,51 tonne-f/m)~~

P_o = the greater of P_c and 5A kN ~~(0,5A tonne-f)~~

P_c = accidental force, in kN ~~(tonne-f)~~, due to loose cargo, etc. to be uniformly distributed over the area A and not to be taken less than 300 kN ~~(30,6 tonne-f)~~. For small doors such as bunker doors and pilot doors, the value of P_c may be taken as zero, provided an additional structure such as an inner ramp is fitted, which is capable of protecting the door from accidental force due to loose cargoes.

8.7 Design of securing and supporting devices

8.7.1 Securing devices and supporting devices are to be designed to withstand the forces given above using the following permissible stresses:

$$\cancel{\tau = \frac{80}{k}\,\text{N/mm}^2 \left(\frac{8{,}2}{\text{k}}\,\text{kgf/mm}^2\right)} \qquad \tau = \frac{80}{k}\,\text{N/mm}^2$$

$$\cancel{\sigma = \frac{120}{k}\,\text{N/mm}^2 \left(\frac{12{,}2}{\text{k}}\,\text{kgf/mm}^2\right)} \qquad \sigma = \frac{120}{k}\,\text{N/mm}^2$$

$\cancel{\sigma_e = \frac{150}{k}\ \text{N/mm}^2 \left(\frac{15{,}3}{k}\ \text{kgf/mm}^2\right)}$ $\sigma_e = \frac{150}{k}\ \text{N/mm}^2$

The terms `securing device' and `supporting device' are defined in *Pt 4, Ch 2, 8.2 General 8.2.8*.

8.7.2 The arrangement of securing and supporting devices is to be such that threaded bolts are not to carry support forces. The maximum tensile stress in way of threads of bolts, not carrying support forces, is not to exceed:

$\cancel{\frac{125}{k}\ \text{N/mm}^2 \left(\frac{12{,}7}{k}\ \text{kgf/mm}^2\right)}$ $\frac{125}{k}\ \text{N/mm}^2$

Part 3, Chapter 13
Ship Control Systems

■ *Section 1*
General

1.2 General symbols

1.2.1 The following symbols and definitions are applicable to this Chapter, unless otherwise stated:

L, *B* and *C* $_b$ as defined in *Pt 3, Ch 1, 6.1 Principal particulars*

σ_o = minimum yield stress or 0,5 per cent proof stress of the material, in N/mm^2~~(kgf/mm^2)~~

k = higher tensile steel factor, *see Pt 3, Ch 2, 1.2 Steel*.

■ *Section 2*
Rudders

2.10 Rudder stock scantlings

Table 13.2.5 Rudder stock permissible stresses

<table>
<tr><th>Mode</th><th>Permissible stress, N/mm^2</th></tr>
<tr><td>(1) Torsional shear stress, τ_t</td><td>$\frac{68}{k}$</td></tr>
<tr><td>(2) Equivalent stress, σ_c</td><td>$\frac{118}{k}$</td></tr>
<tr><td colspan="2">Symbols</td></tr>
<tr><td colspan="2">Equivalent stress:
$\sigma_c = \sqrt{\sigma_b^2 + 3\tau_t^2}$ N/mm^2
Bending stress:
$\sigma_b = 10,2 \times 10^3 \frac{M}{d_c^3}$ N/mm^2
Torsional stress:
$\cancel{\tau_t = 5,2 \times 10^3 \frac{Q_R}{d_c^3}\ \text{N/mm}^2}$ $\tau_t = 5,1 \times 10^3 \frac{Q_R}{d_c^3}$ N/mm^2
M = bending moment, in Nm, at the section of the rudder stock under consideration, *see Pt 3, Ch 13, 2.9 Rudder strength calculation 2.9.2*.
d_c= actual stock diameter, in mm.</td></tr>
</table>

2.16 Pintles

Table 13.2.12 Pintle requirements

Item	Requirement	
(1) Pintle diameter, in mm	$d_P = 0{,}35\sqrt{Bk_p}$	
(2) Pintle taper	Method of assembly	Taper (on diameter)
	Keyed and other manually assembled pintles applying locking by securing nut	1:8 – 1:12
	Pintles mounted with oil injection and hydraulic nut	1:12 – 1:20
(3) Pintle bearing length	~~$d_p \leq l_p \leq 1{,}2d_p$~~ $d_{pl} \leq l_p \leq 1{,}2d_{pl}$	
(4) Pintle housing/gudgeon	~~$b_g \geq 0{,}25\ d_p$~~ $b_g \geq 0{,}25\ d_{pl}$	
(5) Liner or bush in way of pintle bearings, in mm	$t = 0{,}01\sqrt{B}$	

Symbols

k_p = material factor for pintle

B = bearing force, in N

d_p = actual pintle diameter measured ~~on the outside of liners~~ to the inside of the liner, in mm~~.~~
d_{pl} = diameter measured to the outside of the pintle liner, in mm~~.~~

b_g = thickness of pintle housing/gudgeon in way of pintles (measured from the outside of bush if fitted).

~~**Note** 1. The length of the pintle housing in the gudgeon is not to be less than the maximum pintle diameter d_p.~~
Note ~~2~~ 1. The minimum dimensions of threads and nuts are to be determined according to *Table 13.2.11 Securing nut dimensions*.

2.16.5 The required push-up pressure for pintle bearings is to be determined by the following formula:

$$\boldsymbol{p}_{\textbf{req}} = 0{,}4\frac{Bd_p}{{d_m}^2\ell}\ \text{N/mm}^2$$

where
d_m, and l are defined in *Pt 3, Ch 13, 2.15 Cone couplings with special arrangements for mounting and dismounting the couplings 2.15.4*.

~~**B**~~ ***B*** = supporting force in the pintle bearing, in N

$\boldsymbol{d_p}$ = actual pintle diameter, in mm.

The push-up length is to be calculated in accordance with *Pt 3, Ch 13, 2.15 Cone couplings with special arrangements for mounting and dismounting the couplings 2.15.5*, using the required push-up pressure and properties for the pintle bearing.

2.17 Bearings

Table 13.2.13 Bearings

Item	Requirement	
(3) Clearance	Bearing material	Minimum clearance (on diameter)
	Metal	0,001d+1,0
	Synthetic	See Notes 1, 2, 3~~,~~ and 4

Symbols

A_B = bearing surface, in mm^2, defined as the projected area (length x outer diameter) of liner
d = stock diameter, as calculated in ~~Table~~ *Table 13.2.4 Rudder stock diameter*, or pintle diameter as calculated in *Table 13.2.12 Pintle requirements*
B = bearing force, in N~~.~~
q_a = allowable surface pressure, *see Table 13.2.14 Maximum surface pressure*~~.~~

■ *Section 3*
Fixed and steering nozzles

3.1 General

Table 13.3.1 Nozzle construction requirements

Item	Requirement
(1) Nozzle numeral	$N_N = 0,01P\delta_p$ ~~($N_N = 0,00736H\delta_p$)~~
(5) Nozzle stock	Combined stresses in stock at lower bearing ≤ 92,7 N/mm^2 ~~(9,45 kgf/mm^2)~~ Torsional stress in upper stock ≤ 62,0 N/mm^2 ~~(6,3 kgf/mm^2)~~
(6) Solepiece and strut	Bending stresses not to exceed 70,0 N/mm^2 ~~(7,1 kgf/mm^2)~~
Symbols	
~~(H = power transmitted to the propellers, in shp)~~	

■ *Section 6*
Stabiliser structure

6.1 Fin stabilisers

6.1.2 The stabiliser machinery and surrounding structure is to be adequately supported and stiffened. Where bending stresses are induced in the structure under fatigue conditions the maximum stress is not to exceed 39,0 N/mm^2 ~~(4 kgf/mm^2)~~.

■ *Section 7*
Equipment

7.4 Chain cables

7.4.2 Grade U1 material having a tensile stress of less than 400 N/mm^2 ~~(41 kgf/cm^2)~~ is not to be used in association with high holding power anchors. Grade U3 material is to be used only for chain 20,5 mm or more in diameter.

7.6 Towlines and mooring lines for ships over 90 m in length

Table 13.7.3 Equipment – Steam anchors, stream wires, towlines and mooring lines

Note *3.* Wire ropes used for towlines and mooring lines are generally to be of a flexible construction with not less than:
144 wires in six strands with seven fibre cores for strengths up to 490 kN ~~(50 tonne-f)~~.
222 wires in six strands with one fibre core for strengths exceeding 490 kN ~~(50 tonne-f)~~.
The wires laid round the fibre centre of each strand are to be made up in not less than two layers.

Table 13.7.5 Chain cable steel grades

		Tensile strength	
Grade	Material	N/mm^2	~~(kgf/mm^2)~~
U1	Mild steel	300 - 490	~~(31 - 50)~~
U2 (a)	Special quality steel (wrought)	490 - 690	~~(50 - 70)~~
U2 (b)	Special quality steel (cast)	490 - 690	~~(50 - 70)~~
U3	Extra special quality steel	690 min.	~~(70 min.)~~

7.6.2 For ease of handling, fibre ropes are to be not less than 20 mm in diameter. All ropes having breaking strengths in excess of 736,0 kN ~~(75,0 tonne-f)~~ and used in normal mooring operations are to be handled by, and stored on, suitably designed winches. Alternative methods of storing should give due consideration to the difficulties experienced in manually handling ropes having breaking strengths in excess of 490,0 kN ~~(50,0 tonne-f)~~.

■ *Section 8*
Windlass design and testing

8.1 Windlass design

8.1.2 The following performance criteria are to be used as a design basis for the windlass:

(a) The windlass is to have sufficient power to exert a continuous duty pull over a period of 30 minutes of:

- for specified design anchorage depths up to 82,5 m:

Chain cable grade	Duty pull, P, in N ~~(kgf)~~
U1	$37{,}5d_c^2$ ~~($3{,}82d_c^2$)~~
U2	$42{,}5d_c^2$ ~~($4{,}33d_c^2$)~~
U3	$47{,}5d_c^2$ ~~($4{,}84d_c^2$)~~

- for specified design anchorage depths greater than 82,5 m:
  $P_1 = P + (D_a - 82{,}5)\ 0{,}27d_c^2$ N
  ~~[$P_1 = P + (D_a - 82{,}5)\ 0{,}0275d_c^2$ kgf]~~

(b) The windlass is to have sufficient power to exert, over a period of at least two minutes, a pull equal to the greater of:
(ii.) anchor breakout pull:

$$12{,}18W_a + \frac{7{,}0L_c d_c^2}{100}\ \text{N}$$

$$\cancel{\left(1{,}24Wa + \frac{7{,}1L_c d_c^2}{1000}\ \text{kgf}\right)}$$

(c) The windlass, with its braking system in action and in conditions simulating those likely to occur in service, is to be able to withstand, without permanent deformation or brake slip, a load, applied to the cable, given by:
$K_b d_c^2\ (44 - 0{,}08d_c)$ N
~~($K_b d_c^2\ (44 - 0{,}08d_c)$ kgf)~~

Table 13.8.1 Values of K_b

Cable grade	K_b			
	Windless used in conjunction with chain stopper		Chain stopper not fitted	
	N	~~(kgf)~~	N	~~(kgf)~~
U1	4,41	~~(0,45)~~	7,85	(0,8)
U2	6,18	~~(0,63)~~	11,0	~~(1,12)~~
U3	8,83	~~(0,9)~~	15,7	~~(1,6)~~

8.10 Structural requirements associated with anchoring

8.10.8 Provision is to be made for securing the inboard ends of the cables to the structure. This attachment should have a working strength of not less than 63,7 kN ~~(6,5 tonne-f)~~ or 10 per cent of the breaking strength of the chain cable, whichever is the greater, and the structure to which it is attached is to be adequate for this load. Attention is drawn to the advantages of arranging that the cable may be slipped from an accessible position outside the chain cable locker. The proposed arrangement for slipping the chain cable, if constructed outside the chain locker, must be made watertight.

■ *Section 9*
Mooring of ships at single point moorings

9.2 Arrangements

9.2.4 Smit-Type Brackets:

(b) The scantlings of the pin, connecting brackets and welded attachments to the baseplate are to be determined in association with a horizontal load of 2 x SWL and a permissible shear stress of 78 N/mm^2 ~~(8 kg/mm^2)~~.

(e) Adjacent to each Smit-Type Bracket a lug with a recommended safe working load of 490 kN ~~(50 tonnes)~~ should be attached to the doubler plate. The lug should be provided with a hole of sufficient size to accept the pin of a 490 kN ~~(50 tonnes)~~ SWL shackle and should be used as a securing point for the chafe chain holding stopper.

9.2.8 The winch drum used for handling the mooring gear should be capable of exerting a continuous duty pull of not less than 147 kN ~~(15 tonnes)~~ and be of sufficient size to accommodate 150 m of 80 mm diameter rope. Winch drum ends (warping ends) to handle pick-up ropes should be avoided. Remotely-operated winch storage drums are recommended.

Section 10

Emergency towing arrangements

10.1 Structural requirements

Table 13.10.1 Permissible stress values

Permissible stress N/mm^2~~(kgf/mm^2)~~
Symbols
σ_o = specified minimum yield stress, in N/mm^2~~(kgf/mm^2)~~

Part 3, Chapter 14

Cargo Securing Arrangements

Section 9

Strength of container securing arrangements

9.5 Forces in the lashing devices

9.5.3 The elongation of the lashing device may be calculated as follows:

l_z = vertical separation of lashing foundation from container corner casting, in mm, positive downwards
l_r = length of lashing rod or device, in mm
= ~~$\sqrt{(l_x)^2+(l_y)^2+(l_z)^2\omega}$~~ $\sqrt{(l_x)^2+(l_y)^2+(l_z)^2}$
δ_{xi} = total longitudinal racking deflection of the top corner of container *i*, in mm

9.5.4 Where external support is provided by a buttress or shore, the load is to be transmitted between adjacent stacks by linkages in line with the support. The force in the transverse end wall members of the containers adjacent to the support is given by:

$F_b\left(\frac{2N-1}{2N}\right)$ kN and the force in the linkage to the adjacent container is ~~$F_b\left(\frac{N-1}{N}\right)$~~ $F_b\left(\frac{N-1}{N}\right)$ kN

where
~~F_b~~ F_b= calculated force in the buttress or shore, in kN
N = number of rows of containers supported by the buttress or shore.

Part 3, Chapter 16

ShipRight Procedures for the Design, Construction and Lifetime Care of Ships

Section 3

Structural design assessment

3.1 Structural Design Assessment notation – SDA

3.1.1 Where specified in the Rules the ship structure is to be assessed using finite element modelling in accordance with the applicable ShipRight SDA procedures. Where the relevant procedures have been applied whether on a voluntary or mandatory basis the ShipRight notation **SDA** will be assigned, *see also Pt 1, Ch 2, 2.3 Class notations (hull) 2.3.17*. In general the mandatory application criteria for implementation of one of the associated ShipRight SDA procedures is as follows:

(i) upon application of any of the following ShipRight notations: **FDA, FDA plus(), FDA ICE, FDA SPR** ~~and **WDA**~~, **WDA1** and **WDA2**, *see also Pt 3, Ch 16, 4 Fatigue design assessment* and *Pt 3, Ch 16, 5 Whipping design assessment*.

In addition to the above, and where applicable, the structural capability to withstand dynamic loadings from partially filled tanks or the influence of thermal loadings may also be required to be assessed.

■ *Section 5*
Whipping design assessment

5.1 Whipping Design Assessment notations – WDA1 and WDA 2

5.1.1 Where specified in the Rules an appraisal is to be made of the ~~vibrational~~ dynamic response of the hull structure due to wave impact loads (Whipping) in accordance with the relevant ShipRight procedures. Where the relevant procedures have been applied the ShipRight notation ~~WDA~~ Whipping Design Assessment Level 1 **WDA1** will be assigned, *see also Pt 1, Ch 2, 2.3 Class notations (hull) 2.3.17*.

5.1.2 Where specified in the Rules an appraisal is to be made of the dynamic response of the hull structure due to wave impact loads (Whipping) in accordance with the relevant ShipRight procedures. Where the relevant procedures have been applied the ShipRight notation Whipping Design Assessment Level 2 **WDA2** will be assigned, *see also Pt 1, Ch 2, 2.3 Class notations (hull) 2.3.17*.

■ *Section 6*
Ship Event Analysis

6.1 Ship Event Analysis – Descriptive note SEA()

6.1.1 At the Owner's request and in order to enhance safety and awareness on board during ship operation, the *ShipRight Ship Event Analysis Procedure* applies to all ships where it is intended to provide a hull surveillance system for:

(a) Monitoring of the ship's hull girder stresses and motions, and warning the ship's personnel that these stress levels or the frequency and magnitude of slamming motions are approaching a level where corrective action is advisable.

(b) Monitoring of the ship's hull girder stresses and local ice loads when the ship is navigating in ice, and warning the ship's personnel that the load levels or the frequency and magnitude of ice impacts are approaching a level where corrective action is advisable.

The descriptive note is to be appended by HSS followed by the number of strain gauges fitted shown in brackets. In addition the extension of one or more of the following associated supplementary characters may be shown, e.g. **ShipRight(SEA(HSS-2,VDR))**:

L The display of the relevant information in the cargo control area;
M The display and recording of the ship's motion;
N The facility to display and record navigational information;
VDR An interface with the ship's voyage data recorder system to enable the recording of hull stress, ship motion and hull pressure information.

■ *Section 8*
Corrosion protection of internal tanks and spaces

8.1 Protective coating systems in dedicated sea-water ballast tanks and double-side skin spaces – ShipRight Notations ACS(B) or ACS(B,D)

8.1.2 **~~ShipRight~~ ACS(B)** or **~~ShipRight~~ ACS(B,D)** will be entered in Column 4 of the *Register Book* to indicate that the ship's sea water ballast tanks and double-side skin spaces of bulk carriers are coated with approved coating systems according to IMO *Resolution MSC.215(82) - Performance Standard for Protective Coatings for Dedicated Seawater Ballast Tanks in all Types of Ships and Double-Side Skin Spaces of Bulk Carriers - (Adopted on 8 December 2006)*.

8.2 Protective coating systems in the cargo oil tanks of crude oil tankers – ShipRight Notation ACS(C)

8.2.1 For ships that are required to comply with IMO *Resolution MSC.291(87) – Adoption of Amendments to the International Convention for the Safety of Life at Sea, 1974, as Amended – (Adopted on 21 May 2010)*, Owners may request to receive the optional notation **~~ShipRight~~ ACS(C)**, which indicates that the cargo oil tanks are protected in compliance with IMO *Resolution MSC.288(87) – Performance Standard for Protective Coatings for Cargo Oil Tanks of Crude Oil Tankers – (Adopted on 14 May 2010)*, and are to have type approved coating systems applied in accordance with ShipRight Procedure *Anti-Corrosion System Notation* and *Ch 15 Corrosion Prevention* of the Rules for Materials.

8.2.2 **~~ShipRight~~ ACS(C)** will be entered in Column 4 of the *Register Book* to indicate that the ship's cargo oil tanks are protected using approved materials in accordance with IMO *Resolution MSC.291(87) – Adoption of Amendments to the International Convention for the Safety of Life at Sea, 1974, as Amended – (Adopted on 21 May 2010)*.

8.2.3 When in compliance with IMO *Resolution MSC.291(87) – Adoption of Amendments to the International Convention for the Safety of Life at Sea, 1974, as Amended – (Adopted on 21 May 2010)* , but the **~~ShipRight~~ ACS(C)** notation is not requested, this compliance may be indicated on the applicable certification, *Ch 15 Corrosion Prevention* of the Rules for Materials.

8.3 Alternative means of corrosion protection for cargo oil tanks of crude oil tankers – ShipRight notation ACS(C*)

8.3.1 For ships that are required to comply with the IMO *Resolution MSC.291(87) – Adoption of Amendments to the International Convention for the Safety of Life at Sea, 1974, as Amended – (Adopted on 21 May 2010)*, as amended, Owners may request to receive the optional notation ~~**ShipRight**~~ **ACS(C*)**, which indicates that all cargo tanks are protected in accordance with IMO *Resolution MSC.289(87) – Performance Standard for Alternative Means of Corrosion Protection for Cargo Oil Tanks of Crude Oil Tankers – (Adopted on 14 May 2010)* , by application of corrosion resistant steel, *see Ch 3, 1.3 Corrosion resistant steels for cargo oil tanks of crude oil tankers* of the Rules for Materials and ShipRight Procedure *Anti-Corrosion System Notation*.

8.3.2 ~~**ShipRight**~~ **ACS(C*)** will be entered in Column 4 of the Register Book to indicate that the ship's cargo oil tanks are protected using approved materials in accordance with IMO *Resolution MSC.291(87) – Adoption of Amendments to the International Convention for the Safety of Life at Sea, 1974, as Amended – (Adopted on 21 May 2010)* , as amended.

8.3.3 When in compliance with IMO *Resolution MSC.291(87) – Adoption of Amendments to the International Convention for the Safety of Life at Sea, 1974, as Amended – (Adopted on 21 May 2010)* , but the ~~**ShipRight**~~ **ACS(C*)** notation is not requested, this compliance may be indicated on the applicable certificate.

8.4 Protective coatings for void spaces on bulk carriers and oil tankers – ShipRight Notation ACS(V)

8.4.1 For ships within the scope of IMO *Resolution MSC.244(83) - Adoption of Performance Standard for Protective Coatings for Void Spaces on Bulk Carriers and Oil Tankers - (Adopted on 5 October 2007)*, Owners may request to receive the optional notation ~~**ShipRight**~~ **ACS(V)**, which indicates that the void spaces are protected according to the *ShipRight Procedure Anti-Corrosion System Notation*.

8.4.2 ~~**ShipRight**~~ **ACS(V)** will be entered in Column 4 of the *Register Book* to indicate that the ship's void spaces are protected in accordance with IMO *Resolution MSC.244(83) - Adoption of Performance Standard for Protective Coatings for Void Spaces on Bulk Carriers and Oil Tankers - (Adopted on 5 October 2007)*.

8.4.3 When in compliance with IMO *Resolution MSC.244(83) - Adoption of Performance Standard for Protective Coatings for Void Spaces on Bulk Carriers and Oil Tankers - (Adopted on 5 October 2007)*, but the ~~**ShipRight**~~ **ACS(V)** notation is not requested, this compliance may be indicated on the applicable certificate.

8.5 Protective coating systems in dedicated seawater ballast tanks – Descriptive note PCWBT()

8.5.1 For ships that are not required to comply with IMO *Resolution MSC.215(82) - Performance Standard for Protective Coatings for Dedicated Seawater Ballast Tanks in all Types of Ships and Double-Side Skin Spaces of Bulk Carriers - (Adopted on 8 December 2006)*, all sea-water ballast spaces having boundaries formed by the hull envelope are to have a corrosion protection coating applied, *see* ShipRight Procedure *Protective Coatings in Water Ballast Tanks (PCWBT)*. The month and year that the coating is approved is to be appended to the descriptive note within brackets.

8.5.2 Where requested, a descriptive note **PCWBT()** (Protective Coating in Water Ballast Tanks) will be entered in column 6 of the *Register Book* to indicate that all sea-water ballast spaces having boundaries formed by the hull envelope have a corrosion protection coating applied, and that the coating remains efficient and is maintained in good condition. ~~If the coatings have broken down, particularly at more critical areas, and no effort is being made to maintain the coatings, then this note will be placed in parentheses, i.e.~~ ~~**(PCWBT)**~~. ~~In either case, the date of the last survey will be placed in parentheses after the note.~~ The month and year that the coating is approved is to be appended to the descriptive note within brackets.

■ *Section 10*
Assessment of Ballast Water Management Plans

10.1 Ballast Water Management Plans – Descriptive note BWMP()

10.1.1 Compliance with this procedure is optional. A ship meeting the requirements of this procedure will be eligible for an appropriate ~~**ShipRight**~~ **BWMP()** descriptive note, which will be recorded in column 6 of the *Register Book*. The extension of one or more of the following associated supplementary characters may be shown in brackets, detailing the method(s) used:

S	Sequential method
F	Flow through method
D	Dilution method
T	Treatment method.

■ *Section 11*
Inventory of hazardous materials

11.1 Inventory of hazardous materials – Descriptive note IHM

11.1.1 Compliance with this procedure is optional. A ship meeting the requirements of this procedure will be eligible for a ~~ShipRight~~ **IHM** Descriptive Note, which will be recorded in column 6 of the *Register Book*, except as indicated in *Pt 3, Ch 16, 11.1 Inventory of hazardous materials – Descriptive note IHM 11.1.2*.

■ *Section 12*
Safe Return to Port and Orderly Evacuation

12.1 Safe Return to Port and Orderly Evacuation – Descriptive Note SRtP

12.1.1 Compliance with this procedure is optional. A ship meeting the requirements of this procedure will be eligible for a ~~ShipRight~~ **SRtP** Descriptive Note, which will be recorded in column 6 of the *Register Book*.

Part 4, Chapter 1
General Cargo Ships

■ *Section 3*
Longitudinal strength

3.2 Fast cargo ships

3.2.4 For local strength, in general the following requirements are to be complied with:

(d) Deck and side shell panels forward of 0,5*L* from F.P. are to be examined to establish the critical buckling stress from the following formula:

$$\sigma_c = \frac{\pi^2 E}{12\left(1-\nu^2\right)}\left(\frac{t}{s}\right)^2 K_c \text{ N/mm}^2$$ ~~(kgf/mm²)~~

where

E = Young’s modulus, in N/mm^2 ~~(kgf/mm²)~~

Where the buckling stresses, as evaluated, exceed 50 per cent of yield stress, the actual critical buckling stress is given by:

$$\sigma_{ac} = \sigma_o \left(1 - \frac{\sigma_o}{4\sigma_c}\right) \text{N/mm}^2$$ ~~(kgf/mm²)~~

where

σ_{ac} = corrected critical buckling stress, in N/mm^2 ~~(kgf/mm²)~~

σ_o = yield stress, in N/mm^2 ~~(kgf/mm²)~~

The critical buckling stress from the above formulae must be not less than 176,6 N/mm^2 ~~(18,0 kgf/mm²)~~ within 0,4*L* amidships, nor less than 147,2 N/mm^2 ~~(15,0 kgf/mm²)~~ for the deck forward of this, nor less than 117,7 N/mm^2 ~~(12,0 kgf/mm²)~~ for the side shell between the first and second deck forward of 0,5*L* from F.P. For higher tensile steel plating, the above permissible stresses are to be divided by *k*.

■ *Section 4*
Deck Structure

4.3 Deck stiffening

Table 1.4.5 Strength/weather, cargo and accommodation deck beams

Note 1. Where weather decks are intended to carry deck cargo and the load is in excess of 8,5 kN/m^2 ~~(0,865 tonne-f/m²)~~, the scantlings of beams may be required to be increased to comply with the requirements for location (2) using the equivalent design head, for specified cargo loading, for weather decks given in *Table 3.5.1 Design heads and permissible cargo loadings*.

4.4 Deck supporting structure

4.4.9 Where pillars are fitted inside tanks or under watertight flats, the tensile stress in the pillar and its end connections is not to exceed 108 N/mm^2 ~~(11,0 kgf/mm^2)~~ at the test heads. In general, such pillars should be of built sections, and end brackets may be required.

4.5 Deck openings

Table 1.4.7 Pillars

Symbols	Parameter	Requirement
b = breadth of side of a hollow rectangular pillar or breadth of flange or web of a built or rolled section, in mm d_p = mean diameter of tubular pillars, in mm	(1) Cross-sectional area of all types of pillar	$A_p = \dfrac{kP}{12{,}36 - 51{,}5\dfrac{l_e}{r\sqrt{k}}}$ cm^2 $\cancel{\left(A_p = \dfrac{kP}{1{,}26 - 5{,}25\dfrac{l_e}{r\sqrt{k}}}\text{cm}^2\right)}$ *See* Note
k = local scantling higher tensile steel factor, *see Pt 3, Ch 2, 1.2 Steel 1.2.3*, but not less than 0,72 l = overall length of pillar, in metres l_e = effective length of pillar, in metres, and is taken as: for hold pillars 0,65 l for 'tween deck pillars 0,80 l l_p = In single deck ships the section modulus of deck transverses is to be increased by 15 per cent.	(2) Minimum wall thickness of tubular pillars	The greater of the following: (a) $t = \dfrac{P}{d_p\left(0{,}392 - 1{,}53\dfrac{l_e}{r}\right)}$ mm (a) $\cancel{\left(t = \dfrac{P}{d_p\left(0{,}04 - 0{,}156\dfrac{l_e}{r}\right)}\right)}$ mm
r = least radius of gyration of pillar cross-section, in mm, and may be taken as: $r = 10\sqrt{\dfrac{I}{Ap}}$ mm A_p = cross-sectional area of pillar, in cm^2 *C, S* as defined in *Pt 4, Ch 1, 1.5 Symbols and definitions 1.5.1* H_g as defined in *Table 1.4.6 Deck girders, transverses and hatch beams* I = least moment of inertia of cross-section, in cm^4	(3) Minimum wall thickness of hollow rectangular pillars or web plate thickness of **I** or channel sections	The lesser of (b) and (c) and not to be less than (a) (a) $t = \dfrac{P}{b\left(0{,}5 - 1{,}95\dfrac{l_e}{r}\right)}$ mm (a) $\cancel{\left(t = \dfrac{P}{b\left(0{,}05 - 0{,}2\dfrac{l_e}{r}\right)}\right)}$ mm
P = load, in kN ~~(tonne-f)~~, supported by the pillar and is to be taken as $\dfrac{9{,}81 S H_g l_p}{C} + P_a$ $\cancel{\left(\dfrac{S H_g l_p}{C} + P_a\right)}$ but not less than 19,62 kN ~~(2 tonne-f)~~	(4) Minimum thickness of flanges of angle or channel sections	The lesser of the following: (a) $t_f = \dfrac{br}{200 l_e}$ mm (b) $t_f = \dfrac{b}{18}$ mm
P_a = load, in kN ~~(tonne-f)~~, from pillar or pillars above (zero if no pillars over)	(5) Minimum thickness of flanges of built or rolled **I** sections	The lesser of the following: (a) $t_f = \dfrac{br}{400 l_e}$ mm (b) $t_f = \dfrac{b}{36}$ mm
Note As a first approximation A_p may be taken as $\dfrac{\sqrt{k}\,P}{9{,}32}$ $\cancel{\left(\dfrac{\sqrt{k}P}{0{,}95}\right)}$ and the radius of gyration estimated for a suitable section having this area.		

Table 1.4.8 Non-watertight pillar bulkheads

Symbols
A = cross-sectional area, in cm^2, of stiffener and attached plating $A_1 = \dfrac{P}{12{,}36 - 51{,}5\dfrac{l_e}{r}}$ cm^2 $\cancel{\left(A_1 = \dfrac{P}{1{,}26 - 5{,}25\dfrac{l_e}{r}}\right) \text{cm}^2}$ As a first approximation A_1 may be taken as $\dfrac{P}{9{,}32}$ $\cancel{\left(\dfrac{P}{0{,}95}\right)}$ $A_2 = \dfrac{P}{4{,}9 - 14{,}7\dfrac{l_e}{r}}$ cm^2 $\cancel{\left(A_2 = \dfrac{P}{0{,}5 - 1{,}5\dfrac{l_e}{r}} \text{cm}^2\right)}$ As a first approximation A_2 may be taken as $\dfrac{P}{3{,}92}$ $\cancel{\left(\dfrac{P}{0{,}4}\right)}$

Table 1.4.9 Cantilever beams

Symbols
M_o = bending moment, in kN m ~~(tonne-f m)~~, on the cantilever beam due to the load supported by a single cantilever. This bending moment is to be calculated about an axis at a distance u from the end. For hatch side cantilevers with uniformly distributed loading this will equal $\dfrac{4{,}9 S_C u}{C}\left(H_2 B_h + H_3 u\right)$ $\cancel{\left(\dfrac{0{,}5 S_C u}{C}\left(H_2 B_h + H_3 u\right)\right)}$

■ *Section 6*
Shell envelope framing

6.4 Primary supporting structure

Table 1.6.1(a) Shell framing (longitudinal)

Location	Modulus, in cm^3
(2) Side longitudinals in way of double skin tanks or deep tanks, *see* Note 2	The greater of the following: (a) Z as from (1) (b) As required by *Ch1,9* for deep tanks
(3) Bottom and bilge longitudinals, *see* Notes 1, 2, 3 and 4	The greater of the following: (a) $Z = ysk h_{T2} l_e^2 F_1$ (b) $Z = ysk h_{T3} l_e^2 F_1 F_{sb}$
Symbols	
Where h_{T1} ~~and h_{T2}~~ need not exceed 0,86 $\left(h_5 + \dfrac{D_1}{8}\right)$ f or $F_1 \leq$ 0,14 and $\left(h_5 + \dfrac{D_1}{8}\right)$ f or $F_1 >$ 0,14 $h_{T2} = (T + 0{,}5C_W)F_\lambda$, in meters for bottom longitudinals but need not be taken greater than 1,2T	

Table 1.6.2(b) Shell framing (longitudinal)

Location	Modulus, in cm^3
(2) Side longitudinals in way of double skin tanks or deep tanks, *see* Note 2	The greater of the following: (a) Z as from (1) As required by *Pt 4, Ch 1, 9.1 General* for deep tanks using h_{T3} instead of h_4, but need not exceed Z from (3)(b) evaluated using γ, s and fige for the longitudinal under consideration and the remaining parameters evaluated at the base line
(3) Bottom and bilge longitudinals, *see* Notes 1, 2, 3 and 4	The greater of the following: (a) $Z = yskh_{T3}l_e^2F_1F_{sb}$ (b) $Z = yskh_{T3}l_e^2F_1F_{sb}$

Table 1.6.4 Primary structure

Item and location	Modulus, in cm^3
(5) Web frames supporting side stringers	(d) bending stress $\frac{93,2}{k}$ N/mm^2 ~~$\left(\frac{9,5}{k}\text{ kgf/mm}^2\right)$~~ (e) shear stress $\frac{83,4}{k}$ N/mm^2 ~~$\left(\frac{8,5}{k}\text{ kgf/mm}^2\right)$~~

Part 4, Chapter 2
Ferries, Roll On-Roll Off Ships and Passenger Ships

■ *Section 2*
Longitudinal strength

2.4 Design vertical wave bending moments

2.4.1 The minimum value of vertical wave bending moment, M_w at any position along the ship may be taken as follows:
$M_W = f_1 f_2 C_2 M_{WO}$ kNm ~~(tonne-f m)~~
where
$\boldsymbol{M_{WO}} = 0{,}1 C_1 L^2 B_{WL} (C_b + 0{,}7)$ kNm
~~($M_{WO} = 0{,}0102 C_1 L^2 B_{WL} (C_b + 0{,}7)$ tonne-f m)~~

2.5 Design wave shear force

2.5.1 The design vertical wave shear force, Q_w, at any position along the ship is given by:
$Q_w = 3 f_1 K_f M_{WO}/L$ kN ~~(tonne-f)~~

2.6 Buckling strength

Table 2.2.1 Buckling factors of safety, λ

Note The buckling mode of failure of the attached plating is defined as follows:
σ_o = specified minimum yield stress, in N/mm^2 ~~(kgf/mm^2)~~.

■ *Section 3*
Deck structure

3.1 Loading

Table 2.3.1 Design dock loadings (ferries and passenger ships only)

Deck	Design pressures P_s, in kN/m^2 ~~(tonne-f/m^2)~~	
	Secondary structures	Primary structures
Decks in way of accommodation and public spaces, *see* Note	6,38 ~~(0,65)~~	3,12 ~~(0,32)~~
Deck supporting baggage spaces	$3{,}53H_t$ ~~($0{,}36H_t$)~~	$3{,}53H_t$ ~~($0{,}36H_t$)~~
Decks in way of stores and refrigerated spaces	14,13 ~~(1,44)~~	14,13 ~~(1,44)~~
Decks in way of workshop and machinery spaces (excludes A/C machinery spaces)	18,34 ~~(1,87)~~	18,34 ~~(1,87)~~
Magradomes	2,45 ~~(0,25)~~	2,45 ~~(0,25)~~
Balconies	3,92 ~~(0,40)~~	1,96 ~~(0,20)~~
Weather exposed superstructure decks	2,26 ~~(0,23)~~	2,26 ~~(0,23)~~
Weather exposed lifeboat deck	8,44 ~~(0,86)~~	8,44 ~~(0,86)~~

3.3 Deck stiffening

Table 2.3.3 Modulus of deck beams and longitudinals for multi-decked ships with high freeboards

Position of beam/longitudinal	Modulus, in cm^3
Decks, excluding those for the stowage of cargo or vehicles	$Z = 0{,}00083\, f_R\, P_s\, l_e^2\, s\, k$ ~~($Z = 0{,}0081\, f_R\, P_s\, l_e^2\, s\, k$)~~ but not less than: Z = 0,025s
Symbols	
P_s =	deck loading, in kN/m^2 ~~(tonne-f/m^2)~~, *see Table 2.3.1 Design deck loadings (ferries and passenger ships only)*.

3.4 Deck supporting primary structure

3.4.1 The section modulus of primary members supporting four or more point loads or a uniformly distributed load is not to be taken as less than:

$Z = 0{,}673 S P_s k l_e^2 (\text{cm}^3)$

~~($Z = 6{,}60 S P_s k l_e^2$)(cm^3)~~

where

P_S = deck design loading, in kN/m^2 ~~(tonnes/m^2)~~, *see Table 2.3.1 Design deck loadings (ferries and passenger ships only)*.

■ *Section 8*
Bow doors and inner doors

8.1 Symbols

8.1.1 The symbols used in this Section are defined as follows:

σ = bending stress, in N/mm^2 ~~(kgf/mm^2)~~
σ_e = equivalent stress, in N/mm^2 ~~(kgf/mm^2)~~
σ_y = yield stress of the bearing material, in N/mm^2 ~~(kgf/mm^2)~~
τ = shear stress, in N/mm^2 ~~(kgf/mm^2)~~.

8.3 Scantlings

8.3.6 The stiffener webs are to have a net sectional area not less than:

$$A_s = \frac{10Q}{k} \text{ cm}^2$$

τ is to be taken as $\frac{100}{k}$ N/mm^2 $\cancel{\left(\frac{10{,}2}{k}\text{ kgf / mm}^2\right)}$

where

Q = shear force, in kN ~~(tonne-f)~~ calculated using the uniformly distributed external sea pressure, p_e, defined in *Pt 4, Ch 2, 8.6 Design of securing and supporting devices 8.6.1*

8.3.8 The scantlings of such primary members are to be based on direct strength calculations. Normally, formulae for simple beam theory may be applied to determine the bending stress. Members are to be considered to have simply supported end connections. The design load, P_e, is the uniformly distributed external sea pressure. The formulae for P_e given in *Pt 4, Ch 2, 8.6 Design of securing and supporting devices 8.6.1*, may be used with α and β defined as:
The permissible stresses are as follows:

$$\cancel{\tau = \frac{80}{k}\text{ N / mm}^2 \left(\frac{8{,}2}{k}\text{ kgf / mm}^2\right)} \qquad \tau = \frac{80}{k}\text{ N / mm}^2$$

$$\cancel{\sigma = \frac{120}{k}\text{ N / mm}^2 \left(\frac{12{,}2}{\text{k}}\text{ kgf / mm}^2\right)} \qquad \sigma = \frac{120}{k}\text{ N / mm}^2$$

$$\cancel{\sigma_e = \frac{150}{k}\text{ N / mm}^2 \left(\frac{15{,}3}{\text{k}}\text{ kgf / mm}^2\right)} \qquad \sigma_e = \frac{150}{k}\text{ N / mm}^2$$

8.6 Design of securing and supporting devices

8.6.1 The external design forces for securing devices, supporting devices and surrounding structure are to be taken not less than *P*, taking the direction of the pressure into account:

(a) For bow doors:

p_e = 0,8 (0,15V + 0,6$\sqrt{L}$)^2 kN/m^2
= ~~(0,082 (0,15V + 0,6$\sqrt{L}$)^2 tonne-f/m^2~~

or

p_e = 2,75λC_H(0,22 + 0,15 tan α) (0,4V sin β + 0,6$\sqrt{L}$)^2 kN/m^2
~~or~~

= ~~(0,28λC_H(0,22 + 0,15 tan α) (0,4V sin β + 0,6$\sqrt{L}$)^2 kN/m^2~~

whichever is the greater.

(b) For inner doors:

p_e = 0,45L kN/m^2
~~= (0,046L tonne-f/m^2)~~

or:

p_e = 10$_q$ kN/m^2
= ~~(1,02$_q$ tonne-f/m^2)~~

8.6.2 The inner door internal design pressure, considered for the scantlings of securing devices, is not to be less than 25 kN/m^2 ~~(2,5 tonne-f/m^2)~~.

8.6.3 For visor doors, the pivot arrangement is to be such that the visor is self-closing under external loads. The closing moment, M_c, is to be taken as:
$M_c = P_x a + 10Wc - P_z b$ kNm
~~(P_xa + 1,02Wc – P$_z$b tonne-fm)~~

but is not to be less than:

$M_c = 10Wc + 0{,}1\sqrt{(a^2+b^2)(P_x^2+P_z^2)}$ kN m

~~$\left(1{,}02Wc + 0{,}1\sqrt{(a^2+b^2)(P_x^2+P_z^2)}\,\text{tonne} - \text{fm}\right)$~~

8.6.4 For visor doors, two securing devices are to be provided at the lower part of the door, each capable of providing the full reaction force required to prevent opening of the door within the permissible stresses given in *Pt 4, Ch 2, 8.6 Design of securing and supporting devices 8.6.7*. The opening moment M_o, to be balanced by this reaction force, is to be taken as not less than:
$M_o = 10Wd + 5A_x a$ kN m
~~$(1{,}02Wd + 0{,}15A_x a$ tonne-fm)~~

8.6.5 For visor type doors, the securing and supporting devices, excluding hinges, are to be capable of resisting the vertical design force (P_z – 10W) kN ~~($(P_z$ – 1,02W) tonne-f)~~, within the permissible stresses given in *Pt 4, Ch 2, 8.6 Design of securing and supporting devices 8.6.7*.

8.6.6 For side-opening doors, securing devices are to be provided such that in the event of a failure of any single securing device the remainder are capable of providing the full reaction force required to prevent the opening of the door. The permissible stresses given in *Pt 4, Ch 2, 8.6 Design of securing and supporting devices 8.6.7* are not to be exceeded. The opening moment about the hinges to be balanced by this reaction force is not to be less than that calculated when the following loads are applied:
(a) An internal pressure of 5 kN/m^2 ~~(0,51 tonne-f/m^2)~~.
(b) A force of 10*W* kN ~~(1,02W tonne-f)~~ acting forward at the centroid of mass.

8.6.7 Securing devices and supporting devices are to be designed to withstand the forces given above using the following permissible stresses:

$$\tau = \cancel{\frac{80}{k}\,\text{N/mm}^2\left(\frac{8{,}2}{k}\,\text{kgf/mm}^2\right)} \qquad \tau = \frac{80}{k}\,\text{N/mm}^2$$

$$\sigma = \cancel{\frac{120}{k}\,\text{N/mm}^2\left(\frac{12{,}2}{k}\,\text{kgf/mm}^2\right)} \qquad \sigma = \frac{120}{k}\,\text{N/mm}^2$$

$$\sigma_e = \cancel{\frac{150}{k}\,\text{N/mm}^2\left(\frac{15{,}3}{k}\,\text{kgf/mm}^2\right)} \qquad \sigma_e = \frac{150}{k}\,\text{N/mm}^2$$

8.6.8 The arrangement of securing and supporting devices is to be such that threaded bolts are not to carry support forces. The maximum tensile stress in way of threads of bolts, not carrying support forces, is not to exceed:

$$\cancel{\frac{125}{k}\,\text{N/mm}^2\left(\frac{12{,}7}{k}\,\text{kgf/mm}^2\right)} \qquad \frac{125}{k}\,\text{N/mm}^2$$

8.6.12 The hinge or linking arms of a bow door and its supports are to be designed for the static and dynamic opening forces. A minimum wind pressure of 1,5 kN/m^2 ~~(0,153 tonne-f/m^2)~~, acting on the transverse projected area of the door is to be taken into account.

■ *Section 9*
Subdivision structure on vehicle deck

9.6 Scantlings of subdivision doors

Table 2.9.1 Permissible stress values

Symbols
σ_o = specified minimum yield stress, in N/mm^2 ~~(kgf/mm^2)~~

9.7 Closing, securing and supporting of subdivision doors

Table 2.9.2 Permissible stress values

Symbols
σ_o = specified minimum yield stress, in N/mm^2 ~~(kgf/mm^2)~~

Part 4, Chapter 3
Tugs

■ *Section 7*
Towing arrangements

7.2 Towing equipment foundations

7.2.4 Scantlings of deck girders and transverses forming the support structure of towing equipment are to be determined by direct calculations using the following stresses:

~~$\tau = \left(\frac{87}{k}\ \text{N}/\text{mm}^2\right)\left(\frac{8{,}9}{k}\ \text{kgf}/\text{mm}^2\right)$~~ $\tau = \frac{87}{k}\ \text{N}/\text{mm}^2$

~~$\sigma = \frac{150}{k}\ \text{N}/\text{mm}^2 \left(\frac{15{,}3}{k}\ \text{kgf}/\text{mm}^2\right)$~~ $\sigma = \frac{150}{k}\ \text{N}/\text{mm}^2$

~~$\sigma_e = \frac{213}{k}\ \text{N}/\text{mm}^2 \left(\frac{21{,}7}{k}\ \text{kgf}/\text{mm}^2\right)$~~ $\sigma_e = \frac{213}{k}\ \text{N}/\text{mm}^2$

Part 4, Chapter 4
Offshore Support Vessels

■ *Section 3*
Hull envelope plating

3.2 Side shell

Table 4.3.1 Minimum side shell thickness

Ship type	Minimum thickness, mm
~~Standby ships~~ Standby vessel	8

3.3 Weather decks

3.3.1 Where cargo is to be carried on weather decks, the scantlings are to be suitable for the specified loadings. The thickness, *t*, of deck plating is to be not less than the greater of:
Where

t_a = 2,5 mm, in general
= 1,0 mm, for ships with dedicated class notation ~~**Standby ship**~~ **standby vessel**.

■ *Section 4*
Hull envelope framing

4.1 General

4.1.1 The section moduli of side longitudinals, the main and 'tween deck frames are to be not less than kZ, cm^3
where

k = 1,25 in general
= 1,10 for ships with dedicated class notation ~~**Standby ship**~~ **standby vessel**

Part 4, Chapter 5
Barges and Pontoons

■ *Section 2*
Longitudinal strength

2.1 General

2.1.3 For shipborne barges, where it is the intention to lift the barge on board ship by crane, a condition `fully loaded barge suspended by crane' is to be submitted. For this condition the following stresses are permissible:

- Bending stress σ_b = 147,2 N/mm^2 ~~(15,0 kgf/mm^2)~~
- Shear stress τ = 98,1 N/mm^2 ~~(10,0 kgf/mm^2)~~

Part 4, Chapter 7
Bulk Carriers

■ *Section 3*
Longitudinal strength

3.2 Hull vertical bending stresses for flooded conditions

3.2.1 The maximum hull vertical bending stresses in the flooded condition at deck, σ_{Df}, and keel, σ_{Bf}, for use in *Pt 3, Ch 4 Longitudinal Strength* are given by the following, using the appropriate combination of bending moments to give sagging and hogging stresses:

~~$\sigma_{Df} = \dfrac{|M_{sf}+0{,}8\ M_{\mathrm{w}}|\mathrm{x}\ 10^{-3}}{Z_{\mathrm{D}}}$ N/mm^2 (kgf/mm^2)~~ $\sigma_{Df} = \dfrac{|M_{\mathrm{sf}}+0{,}8\ M_{\mathrm{w}}|\mathrm{x}\ 10^{-3}}{Z_{\mathrm{D}}}$ N/mm^2

~~$\sigma_{Bf} = \dfrac{|M_{sf}+0{,}8\ M_{\mathrm{w}}|\ \mathrm{x}\ 10^{-3}}{Z_{\mathrm{B}}}$ N/mm^2 (kgf/mm^2)~~ $\sigma_{Bf} = \dfrac{|M_{\mathrm{sf}}+0{,}8\ M_{\mathrm{w}}|\ \mathrm{x}\ 10^{-3}}{Z_{\mathrm{B}}}$ N/mm^2

where

***M* sf** = maximum still water bending moment in the flooded condition, in kN m ~~(tonne-f m)~~, at the section under consideration, *see Pt 4, Ch 7, 3.4 Flooded conditions*

***M* w** = design hull vertical wave bending moment, in kN m ~~(tonne-f m)~~, as defined in *Pt 3, Ch 4, 5 Hull bending strength* at the section under consideration

3.3 Shear stresses for flooded conditions

3.3.1 The shear stress, τ_{Af}, in the flooded condition to be used in *Pt 3, Ch 4, 6 Hull shear strength* , is to be taken as:

$$\tau_{\mathrm{Af}} = 100Az\,\frac{|\mathrm{Q}_{\mathrm{sf}}| + |0{,}8Q_{\mathrm{w}}|}{I\delta_{\mathrm{i}}}\ \text{N/mm}^2$$

~~$\left(\tau_{\mathrm{Af}} = 10{,}2Az\,\dfrac{|Q_{\mathrm{sf}}| + |0{,}8Q_{\mathrm{w}}|}{I\delta_{\mathrm{i}}}\ \mathrm{kgf/mm^2}\right)$~~

where

***Q* sf** = maximum hull still water shear force, in kN ~~(tonne-f)~~, in the flooded condition at the section under consideration

***Q* w** = design hull wave shear force, in kN ~~(tonne-f)~~, as defined in *Pt 3, Ch 4, 6.3 Design wave shear force* at the section under consideration

■ *Section 8*
Double bottom structure

8.8 Allowable hold loading in the flooded condition

8.8.7 The shear strengths, S_{f1}, of floors adjacent to hoppers, and S_{f2}, of floors in way of openings in bays nearest to the hoppers, are as follows:

S_{f1} = 0,001 $A_f\ \tau_p/\eta_1$ kN ~~(tonne-f)~~

S_{f2} = 0,001 $A_{f,h}\ \tau_p/\eta_2$ kN ~~(tonne-f)~~

where

σ_0 = specified minimum yield stress, in N/mm^2 ~~(kgf/mm^2)~~

τ_0 = $\dfrac{\sigma_0}{\sqrt{3}}$ N/mm^2 ~~(kgf/mm^2)~~ and

τ_c = $\dfrac{162\,\sigma^{0,6}{}_0}{(s_1/t_{\text{net}})^{0,8}}$ N/mm^2

~~= $\left(\tau_c\ \dfrac{65\,\sigma^{0,6}{}_0}{(s_1/t_{\text{net}})^{0,8}}\right.$ kgf/mm^2)~~

For floors adjacent to the stools (or bulkhead plating if no lower stools are fitted), τ_p may be taken as $\dfrac{\sigma_0}{\sqrt{3}}$ N/mm^2 ~~(kgf/mm^2)~~.

8.8.8 The shear strengths S_{g1}, of girders adjacent to transverse bulkhead lower stools (or transverse bulkheads if no lower stools are fitted), and S_{g2}, of girders in way of the largest openings in bays nearest to the lower stools (or transverse bulkheads if no lower stools are fitted), are as follows:

S_{g1} = $0{,}001\ A_g\ \tau_p/\eta_1$ kN ~~(tonne-f)~~

S_{g2} = $0{,}001\ A_{g,h}\ \tau_p/\eta_2$ kN ~~(tonne-f)~~

8.8.9 The permissible cargo hold loading, W_p, is given by:

W_p = $g\ \rho_c\ V/F_c$ kN

~~(**W_p** = $\rho_c\ V/F_c$ tonne-f)~~

h_1 = $\dfrac{X}{\rho_c g}$ where Y is in kN/m^2

~~(h_1 = $\dfrac{X}{\rho_c}$ where Y is in tonne-f/m^2)~~

where

X_1 = $\dfrac{Y+\rho g(T_F-h_f)}{1+\left(\dfrac{\rho}{\rho_c}\right)(\mu-1)}$ where Y is in kN/m^2

where

~~(**X_1** = $\dfrac{Y+\rho g(T_F-h_f)}{1+\left(\dfrac{\rho}{\rho_c}\right)(\mu-1)}$ where Y is in tonne-f/m^2~~

X_2 = $Y + \rho\ g\ (T_F - h_f\ \mu)$ where Y is in kN/m^2

~~(**X_2** = $Y + \rho\ (T_F - h_f\ \mu)$ where Y is in tonne-f/m^2)~~

■ *Section 10*
Bulkheads

10.5 Vertically corrugated transverse watertight bulkheads – Scantling assessment

10.5.1 The bending moment M, in kNm ~~(tonne-f m)~~, for the bulkhead corrugations is given by:

$M = \dfrac{Fl}{8}$

F = resultant force, in kN ~~(tonne-f)~~, *see Table 7.10.3 Resultant pressure and force*.

10.5.2 The shear force, Q, in kN ~~(tonne-f)~~ at the lower end of the bulkhead corrugation is given by:

Table 7.10.2 Bulkhead pressure and force

Symbols		
p_c, p_{cf}, p_f	=	pressure on the bulkhead at the point under consideration, in kN/m^2 ~~(tonne-f/m^2)~~
p_{le}	=	pressure at the lower end of the corrugation, in kN/m^2 ~~(tonne-f/m^2)~~

Table 7.10.3 Resultant pressure and force

Loading condition	Resultant pressure kN/m^2 ~~(tonne-f/m^2)~~	Resultant force kN ~~(tonne-f)~~

10.5.5 The bending capacity of the bulkhead corrugations is to comply with the following relationship:

where

M = bending moment, in kNm ~~(tonne-f m)~~, *see Pt 4, Ch 7, 10.5 Vertically corrugated transverse watertight bulkheads – Scantling assessment 10.5.1*

$\sigma_{p,le}$ = permissible bending stress at the lower end of the corrugations, in N/mm^2 ~~(kgf/mm^2)~~

$\sigma_{p,m}$ = permissible bending stress at mid-span of the corrugations, in N/mm^2 ~~(kgf/mm^2)~~

p_g = resultant pressure calculated in way of the middle of the shedder or gusset plates as appropriate, in kN/m^2 ~~(tonne- f/m^2)~~

Q = shear force, in kN ~~(tonne-f)~~, *see Pt 4, Ch 7, 10.5 Vertically corrugated transverse watertight bulkheads – Scantling assessment 10.5.2*

10.5.6 The applied shear stress, in N/mm^2 ~~(kgf/mm^2)~~, is determined by dividing the shear force derived from *Pt 4, Ch 7, 10.5 Vertically corrugated transverse watertight bulkheads – Scantling assessment 10.5.2* by the shear area of the corrugation, calculated using the net plate thickness. The shear area is to be reduced to account for non-perpendicularity between the corrugation webs and flanges. In general, the reduced area may be obtained by multiplying the web sectional area by sin φ, where φ is the angle between the web and the flange, *see Figure 7.10.2 Dimensions of bulkhead corrugation angles*. The applied shear stress is not to exceed the permissible shear stress or the shear buckling stress given in *Table 7.10.4 Permissible shear and buckling stresses*.

Table 7.10.4 Permissible shear and buckling stresses

Bending, N/mm^2 ~~(kgf/mm^2)~~	Shear, N/mm^2 ~~(kgf/mm^2)~~	Shear buckling, N/mm^2 ~~(kgf/mm^2)~~
Symbols		
E = modulus of elasticity = 206 000 N/mm^2 ~~(21000 kgf/mm^2)~~ σ_0 = specified minimum yield stress, in N/mm^2 ~~(kgf/mm^2)~~ τ_E = 5,706 $E\,(t_w/1000c)^2$ N/mm^2 ~~(kgf/mm^2)~~ τ_0 = $\frac{\sigma_0}{\sqrt{3}}$ N/mm^2 ~~(kgf/mm^2)~~		

10.5.8 The corrugation flange and web local net plate thickness are not to be less than:

where

p_r = resultant pressure, in kN/m^2 ~~(tonne-f/m^2)~~, as defined in *Table 7.10.3 Resultant pressure and force*, at the lower edge of each strake of plating. The net thickness of the lowest strake is to be determined using the resultant pressure at the top of the lower stool, (or at the inner bottom, if no lower stool is fitted), or at the top of the shedders, if effective shedder or gusset and shedder plates are fitted

σ_0 = specified minimum yield stress of the material, in N/mm^2 ~~(kgf/mm^2)~~.

■ *Section 12*
Steel hatch covers

12.5 Allowable stress

Table 7.12.2 Permissible stresses

Failure mode	Permissible stress, in N/mm^2 ~~(kgf/mm^2)~~
Symbols	
σ_F = minimum upper yield stress, in N/mm^2 ~~(kgf/mm^2)~~	

Part 4, Chapter 8
Container Ships

■ *Section 2*
Materials

2.3 Requirements for use of thick steel plates

2.3.7 The following are considered to be acceptable examples of brittle crack arrest design for the case given ~~in*Pt 4, Ch 8, 2.3 Requirements for use of thick steel plates 2.3.4*~~ in *Pt 4, Ch 8, 2.3 Requirements for use of thick steel plates 2.3.4* and *Pt 4, Ch 8, 2.3 Requirements for use of thick steel plates 2.3.4*:

(a) Where the block-to-block butt welds of the hatch side coaming and those of the upper deck are staggered, this offset is to be greater than or equal to 300 mm. This offset distance is defined ~~in*Figure 8.2.2 Minimum offset between block-to-block butt welds of the hatch side coaming and those of the upper deck staggered*~~ in *Figure 8.2.2 Minimum offset between block-to-block butt welds of the hatch side coaming and those of the upper deck staggered*. Brittle crack arrest steel, as defined in *Pt 4, Ch 8, 2.3 Requirements for use of thick steel plates 2.3.9*, is to be provided for the hatch side coaming.

■ *Section 3*
Longitudinal strength

3.2 Longitundinal strength

3.2.2 The values of sagging f_{fS} and hogging f_{fH} correction factors due to non-linear effects of the hull shape are to be calculated in accordance with *Pt 4, Ch 8, 16.6 Design vertical wave bending moments 16.6.1* and are to be used in ~~*Pt 3, Ch 4, 5.2 Design vertical wave bending moments 5.2.1* and~~ *Pt 4, Ch 8, 14.2 Procedures for verification of primary structure scantlings 14.2.1*.

■ *Section 7*
Double bottom structure

7.6 Support for containers

Table 8.7.1 Permissible stress values

Permissible stress, N/mm^2 ~~(kgf/mm^2)~~
Symbols
σ_o = specified minimum yield stress, in N/mm^2 ~~(kgf/mm^2)~~

■ *Section 12*
Strengthening for wave impact loads

12.1 General

Table 8.12.1 Critical shear buckling stress for web plating of primary support structure

$\tau_A \leq \tau_{CRB}$

where

$\tau_{CRB} = \tau_E$ N/mm^2 ~~(kg-f/mm^2)~~ when $\tau_E \leq \dfrac{\tau_0}{2}$

$\tau_{CRB} = \tau_0 \left(1 - \dfrac{\tau_0}{4\tau_E}\right)$ N/mm^2 ~~(kg-f/mm^2)~~ when $\tau_E > \dfrac{\tau_0}{2}$

where

$\tau_E = 36 \left[1{,}335 + \left(\dfrac{s}{1000S}\right)^2\right] E \left(\dfrac{\tau_p}{s}\right)^2$ N/mm^2 ~~(kg-f/mm^2)~~

Symbols

τ_A = design shear stress for the web panel in N/mm^2 ~~(kgf/mm^2)~~ corresponding to the worst combination of application of the slamming load P_{bf} on the patch area A_{sl}

τ_{CRB} = critical buckling stress in shear, N/mm^2 ~~(kgf/mm^2)~~ corrected for yielding effects

σ_o = specified minimum yield stress, in N/mm^2 ~~(kgf/mm^2)~~

τ_E = elastic critical buckling stress in shear, in N/mm^2 ~~(kgf/mm^2)~~

E = modulus of elasticity, in N/mm^2 ~~(kgf/mm^2)~~

= 206000 N/mm^2 ~~(21000 kgf/mm^2)~~ for steel

■ *Section 14*
Direct calculation

14.3 Procedures for verification of structural response due to whipping, springing and failure

Table 8.14.1 Summary of direct calculation analysis requirements for container ships

Note 4 A Level 2 Whipping Assessment may be carried out instead of a Level 1 Whipping assessment at the Owner's request. Where a level 2 Whipping Assessment is undertaken, a Level 1 Whipping Assessment need not be carried out.

■ *Section 15*
Requirements for ships with large deck openings

15.2 Symbols and definitions

15.2.1 The following symbols and definitions are applicable to this Section unless otherwise stated:

M_S = design still water bending moment at the section under consideration, in kN m ~~(tonne-f-m)~~

15.3 Design loadings

15.3.1 The design vertical wave bending moments, M_{WC1} and M_{WC2}, at any position along the ship is defined as:

M_{WC1} = $0{,}0505 C_0\, C_{31}\, L^2\, B\, (C_b + 0{,}7)$ kN m

~~= (0,0052 $C_0\, C_{31} L^2\, B\, (C_b + 0{,}7)$ tonne-f-m)~~

M_{WC2} = $0{,}0505 C_0\, C_{32}\, L^2\, B\, (C_b + 0{,}7)$ kN m

~~= (0,0052 $C_0\, C_{32} L^2\, B\, (C_b + 0{,}7)$ tonne-f-m)~~

15.3.2 The design horizontal wave bending moments, M_{HC1} and M_{HC2}, at any position along the ship are defined as:

$\boldsymbol{M_{HC1}}$ = $0,2063C_0\,C_{41}\,L^2\,T\,(C_b + 0,7)$ kN m

~~= $(0,0210C_0\,C_{41}\,L^2\,T\,(C_b + 0,7)$ tonne-f-m)~~

$\boldsymbol{M_{HC2}}$ = $0,2063C_0\,C_{42}\,L^2\,T\,(C_b + 0,7)$ kN m

~~= $(0,0210C_0\,C_{42}\,L^2\,T\,(C_b + 0,7)$ tonne-f-m)~~

15.3.3 The design hydrodynamic torques, M_{WTC1} and M_{WTC2}, at any position along the ship are defined as:

$\boldsymbol{M_{WTCB1}}$ = $0,0728C_0\,C_{51}\,L\,B^2\,(C_b + 0,7)$ kN m

~~= $(0,0074C_0\,C_{51}\,L\,B^2\,(C_b + 0,7)$ tonne-f-m)~~

$\boldsymbol{M_{WTCQ1}}$ = $-(0,65T + \varepsilon)\,Q_{HC1}$ kN m ~~(tonne-f-m)~~

$\boldsymbol{M_{WTCB2}}$ = $0,0728C_0\,C_{52}\,L\,B^2\,(C_b + 0,7)$ kN m

~~= $(0,0074C_0\,C_{52}\,L\,B^2\,(C_b + 0,7)$ tonne-f-m)~~

$\boldsymbol{M_{WTCQ2}}$ = $-(0,65T + \varepsilon)\,Q_{HC2}$ kN m ~~(tonne-f-m)~~

C_0 is defined in *Pt 4, Ch 8, 15.3 Design loadings 15.3.1*

$\boldsymbol{Q_{HC1}}$ = $0,8683C_0\,K_{31}\,L\,T\,(C_b + 0,7)$ kN

~~= $(0,0886C_0\,K_{31}\,L\,T\,(C_b + 0,7)$ tonne-f)~~

$\boldsymbol{Q_{HC2}}$ = $0,8683C_0\,K_{32}\,L\,T\,(C_b + 0,7)$ kN

~~= $(0,0886C_0\,K_{32}\,L\,T\,(C_b + 0,7)$ tonne-f)~~

15.3.4 The design value of static cargo torque, M_{STC}, at any position along the ship is defined as:

$\boldsymbol{M_{STC}}$ = $15,7C_6\,B\,(\eta_s\,\eta_t + 0,7N_{sd}\,N_{td})$ kNm

~~= $(1,6C_6\,B\,(\eta_s\,\eta_t + 0,7N_{sd}\,N_{td})$ tonne-f/m)~~

15.4 Combined stress

15.4.2 The combined stress, σ_c, is to be less than the permissible stress given in *Table 8.15.4 Permissible stress*. σ_c, is to be taken as the greatest magnitude of the following stresses:

~~$\sigma_{c2} = -\sqrt{(\sigma_1 - (1-f)\,\sigma_{WC1})^2 + (\sigma_2 - (1-f)\,\sigma_{WC2})^2} + \sigma_{SC} + |\sigma_{STC}|$~~

$\sigma_{c2} = -\sqrt{(\sigma_1 - (1-f)\,\sigma_{WC1})^2 + (\sigma_2 - (1-f)\,\sigma_{WC2})^2} + \sigma_{SC} - |\sigma_{STC}|$

~~$\sigma'_{c1} = -\sqrt{(\sigma'_1 - (1-f)\,\sigma_{WC1})^2 + (\sigma'_2 - (1-f)\,\sigma_{WC2})^2} + \sigma_{SC} - |\sigma_{STC}|$~~

$\sigma'_{c1} = -\sqrt{(\sigma'_1 - (1-f)\,\sigma_{WC1})^2 + (\sigma'_2 - (1-f)\,\sigma_{WC2})^2} + \sigma_{SC} + |\sigma_{STC}|$

~~$\sigma'_{c2} = -\sqrt{(\sigma'_1 - (1-f)\,\sigma_{WC1})^2 + (\sigma'_2 + (1-f)\,\sigma_{WC2})^2} + \sigma_{SC} - |\sigma_{STC}|$~~

$\sigma'_{c2} = -\sqrt{(\sigma'_1 - (1-f)\,\sigma_{WC1})^2 + (\sigma'_2 - (1-f)\,\sigma_{WC2})^2} + \sigma_{SC} - |\sigma_{STC}|$

15.4.4 For ships with a beam less than or equal to 32 m, the longitudinal stresses may be obtained as follows:

$\boldsymbol{\sigma_{SC}}$ = $\dfrac{M_s}{Z_y} \times 10^{-3}$ N/mm^2 ~~(kgf/mm^2)~~

$\boldsymbol{\sigma_{WC}}$ = $\dfrac{M_{wc}}{Z_y} \times 10^{-3}$ N/mm^2 ~~(kgf/mm^2)~~

$\boldsymbol{\sigma_{HC1}}$ = $C_7\dfrac{M_{HC1}}{Z_z} \times 10^{-3}$ N/mm^2 ~~(kgf/mm^2)~~

$\boldsymbol{\sigma_{HC2}}$ = $C_7\dfrac{M_{HC2}}{Z_z} \times 10^{-3}$ N/mm^2 ~~(kgf/mm^2)~~

15.5 Permissible stress

Table 8.15.4 Permissible stress

Position	Permissible combined stress, N/mm^2 ~~(kgf/mm^2)~~
Top of continuous hatch coaming	$\sigma_c = \frac{175}{k_L} \cancel{\left(\frac{17,84}{k_L}\right)}$
Elsewhere	$\sigma_c = \frac{157}{k_L} \cancel{\left(\frac{16,0}{k_L}\right)}$

Part 4, Chapter 9
Double Hull Oil Tankers

■ *Section 4*
Hull envelope plating

4.2 Symbols

4.2.1 The symbols used in this Section are defined as follows:
where

σ_c = maximum compressive hull vertical bending stress, in N/mm^2 ~~(kgf/mm^2)~~ given by σ_D and σ_B as defined in *Pt 3, Ch 4, 5.6 Permissible hull vertical bending stresses 5.6.1* as appropriate

= For ships of normal design, not exceeding 90 metres in length, the value of maximum compressive hull vertical bending stress may be determined as follows:

= at strength deck

= $\sigma_D = 654LB \frac{Z_{min}}{Z_D} \sigma \text{ x } 10^{-6}$ N/mm^2 ~~(kgf/mm^2)~~

= $\sigma_B = 654LB \frac{Z_{min}}{Z_B} \sigma \text{ x } 10^{-6}$ N/mm^2 ~~(kgf/mm^2)~~

σ_o = specified minimum yield stress, in N/mm^2 ~~(kgf/mm^2)~~

■ *Section 8*
Non-oiltight bulkheads

8.2 Symbols

8.2.1 The symbols used in this Section are defined as follows:

$\tau = \frac{110}{k_L}$ N/mm^2 $\cancel{\left(\frac{11,2}{k_L} \text{ kgf / mm}^2\right)}$

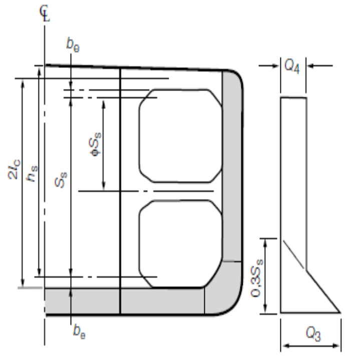
Q_{SL} = the maximum still water shear force on the longitudinal bulkhead, in kN ~~(tonne-f)~~, of the loading condition in question.

Q_{SW} = design wave shear force on the longitudinal bulkhead, in kN ~~(tonne-f)~~.

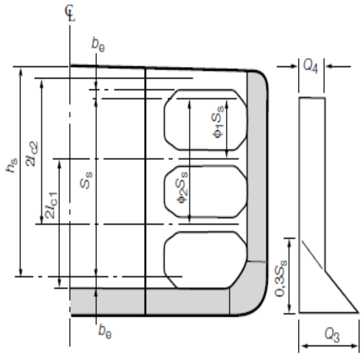
■ *Section 9*

Primary members supporting longitudinal framing

9.3 Girders and floors in double bottom



(a) One cross-tie



(b) Two cross-ties

NOTE: $Q_3 = 9{,}81 K_4 h_s s S_s$ kN
~~($Q_3 = K_4 h_s s S_s$ tonne-f)~~

$Q_4 = 9{,}81 K_5 h_s s S_s$ kN
~~($Q_4 = K_5 h_s s S_s$ tonne-f)~~

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Figure 9.9.1 Wing tank construction

9.7 Primary members supporting oiltight bulkheads

9.7.5 In ships with two longitudinal bulkheads, the net sectional area of the web at any section is not to be less than:

$A = 0{,}12 Q_x k$ cm^2

$$\cancel{\left(A = \frac{Q_x k}{0{,}85}\,\text{cm}^2\right)}$$

Part 4, Chapter 10
Single Hull Oil Tankers

■ *Section 2*
Primary members supporting longitudinal framing

2.2 Symbols

2.2.1 The symbols used in this Section are defined as follows:

Q_x = shear force at the actual section under consideration, obtained from shear force diagrams constructed as indicated, in kN ~~(tonne-f)~~

2.5 Bottom transverses

2.5.2 In ships with two longitudinal bulkheads, the depth of the bottom transverse web plate is to be not less than $0,2S_T$ and the net sectional area of the web at any section, including vertical end connections, is to be not less than:

$A = 0,12 Q_x k$ cm^2

~~$\left(A = \frac{Q_x k}{0,85} \text{ cm}^2\right)$~~

2.6 Bottom girders

2.6.2 The net sectional area of the web at any section, including vertical end connections, is to be not less than:

$A = 0,12 Q_x k$ cm^2

~~$\left(A = \frac{Q_x k}{0,85} \text{ cm}^2\right)$~~

2.7 Side transverses

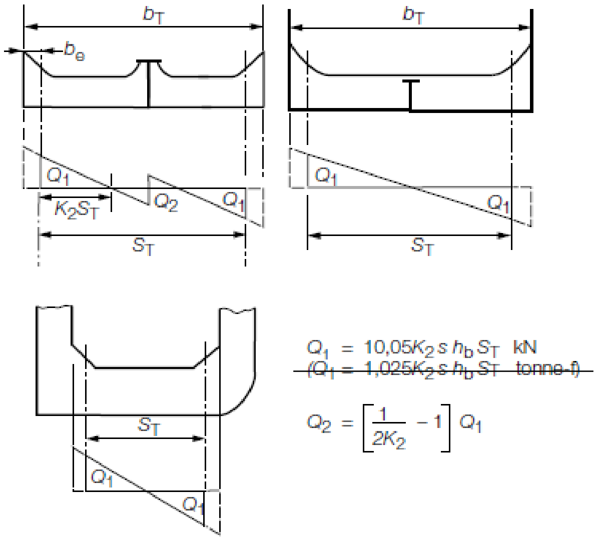
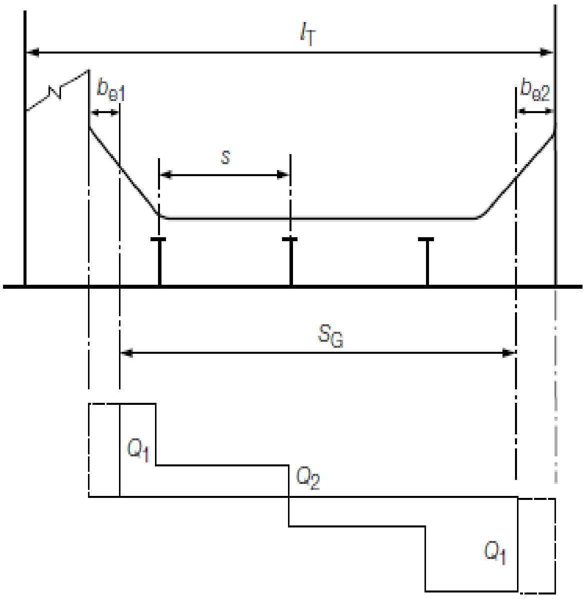

b_T
b_e
b_T
Q_1
$K_2 S_T$
Q_2
Q_1
S_T
Q_1
Q_1
S_T
S_T
Q_1
Q_1
$Q_1 = 10,05 K_2 s h_b S_T$ kN
~~$(Q_1 = 1,025 K_2 s h_b S_T$ tonne-f)~~
$Q_2 = \left[\frac{1}{2K_2} - 1\right] Q_1$

Figure 10.2.1 Bottom transverses



$Q_1 = 5{,}025 K_2\, h_b\, s\, b_T$ kN

~~($Q_1 = 0{,}513 K_2\, h_b\, s\, b_T$ tonne-f)~~

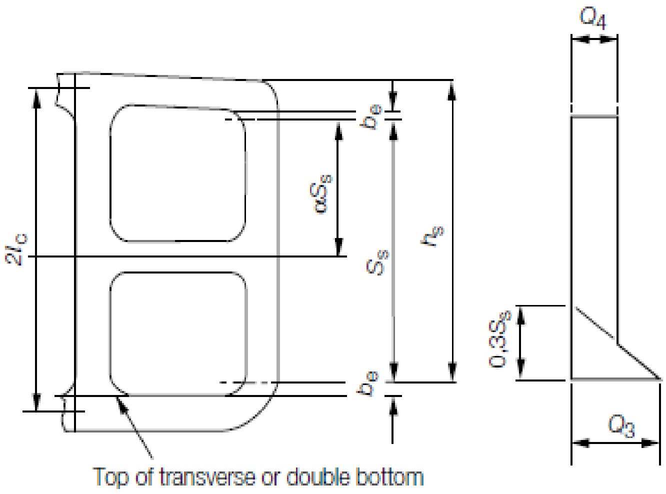
$$Q_2 = \left[\frac{l_T - 3s}{l_T - s}\right] Q_1$$

Figure 10.2.2 Bottom centreline girder

2.7.2 In ships with two longitudinal bulkheads, the net sectional area of the web at any section is to be not less than:

$A = 0,12 Q_x k$ cm^2

$$\cancel{\left(A = \frac{Q_x k}{0,85}\ \text{cm}^2\right)}$$



One cross-tie

NOTE:

$Q_3 = 9,81 k_4 h_s s S_s$ kN

$\cancel{(Q_3 = k_4 h_s s S_s\ \text{tonne-f})}$

$Q_4 = 9,81 k_5 h_s s S_s$ kN

$\cancel{(Q_4 = k_5 h_s s S_s\ \text{tonne-f})}$

Figure 10.2.3 Wing tank construction

■ *Section 3*
Primary members supporting transverse side framing

3.4 Scantlings

3.4.2 The net sectional area of the web at any section is to be not less than:

$A = 0,12 Q_x k$ cm^2

$$\cancel{\left(A = \frac{Q_x k}{0,85}\ \text{cm}^2\right)}$$

$Q_1 = 5,03 s h_1 S_1$ kN

~~$(Q_1 = 0,513 s h_1 S_1$ tonne-f)~~

■ *Section 4*
Primary members supporting oiltight bulkheads

4.2 Symbols

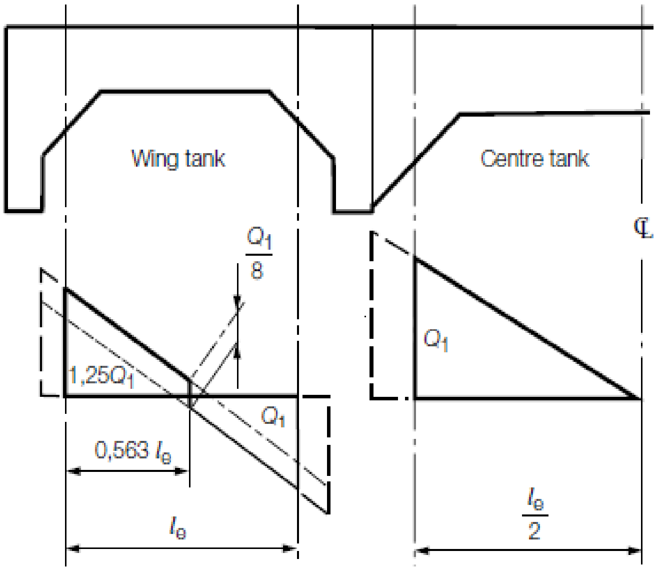
4.2.1 The symbols used in this Section are defined as follows:

Q_x = shear force at the actual section under consideration, obtained from shear force diagrams constructed as indicated, in kN ~~(tonne-f)~~.

4.4 Scantlings

4.4.3 The net sectional area of the web at any section is to be not less than:
$A = 0{,}12 Q_x k$ cm^2

$$\cancel{\left(A = \frac{Q_x k}{0{,}85} \text{ cm}^2\right)}$$



$Q_1 = 5{,}03 b\, h\, l_e$ kN
~~($Q_1 = 0{,}513 b\, h\, l_e$ tonne-f)~~

Figure 10.4.1 Horizontal girders

Part 4, Chapter 12
Dredging and Reclamation Craft

■ *Section 1*
General

1.5 Symbols

1.5.1 The following symbols and definitions are applicable to this Chapter unless otherwise stated:

M_s = design still water bending moment, in kNm ~~(tonne-f m)~~, at draught, *T*, or less

$\overline{M}_s$ = maximum permissible still water bending moment, in kNm ~~(tonne-f m)~~, at draught, *T*, or less

M_{sm} = design still water bending moment, in kNm ~~(tonne-f m)~~, under dredging conditions at draught, T_m

$\overline{M}_{sm}$ = maximum permissible still water bending moment, in kNm ~~(tonne-f m)~~, under dredging conditions at draught, T_m

M_w = design hull vertical wave bending moment amidships, in kN m ~~(tonne-f m)~~, *see Pt 4, Ch 12, 2.4 Design vertical wave bending moments 2.4.1*

■ *Section 2*
Longitudinal strength

2.5 Permissible still water bending moment for dredging conditions

2.5.1 The maximum permissible still water bending moment, $\overline{M}_{\text{sm}}$, for dredging conditions where draught T_{m} exceeds T is not to exceed:

$\left|\overline{M}_{\text{sm}}\right| = \left|\overline{M}_{\text{s}} + f_1\, f_2 M_{\text{wo}} - M_{\text{wd}}\right|$ kNm ~~(tonne-fm)~~

■ *Section 4*
Shell envelope plating

4.6 Side shell

4.6.1 The thickness of the side shell is to be in accordance with *Pt 4, Ch 1, 5.4 Side shell*. On ships classed **A1 protected waters service** the thickness of the side shell throughout, including at ends, may be reduced by 20 per cent from that required by *Pt 4, Ch 1, 5.4 Side shell* and *Pt 3, Ch 5 Fore End Structure* and *Pt 3, Ch 6 Aft End Structure* as appropriate, provided that the combined shear stress does not exceed 110 N/mm^2 ~~(11,2 kgf/mm^2)~~.

■ *Section 17*
Split hopper dredgers and barges

17.1 Symbols and definitions

17.1.1 The symbols used in this Section are defined as follows:

M_{H} = design horizontal bending moment in hopper side wall, in kN m ~~(tonne-f m)~~. A moment giving rise to tensile stress in the side shell is to be taken as positive

P = net pressure per metre ship length resulting from the spoil pressure and the hydrostatic load, *see Figure 12.17.2 Split hopper dredger*

= 4,9 (p (H – H_{s})^2 – 1,025 (T – H_{s})^2) kN/m

= ~~(0,5 (p (H – H_{s})^2 – 1,025 (T – H_{s})^2) tonne-f/m)~~

17.2 Hull bending strength

17.2.1 The modulus of the cross-section of the vessel is to be not less than that required by *Pt 4, Ch 12, 2.3 Hull bending strength 2.3.1.* In addition, the combined stress σ$_{\text{c}}$, at any point on the cross-section of one half hull, is not to exceed the permissible combined stress σ given in *Pt 3, Ch 4, 5.5 Permissible still water bending moments*. The combined stress at any point on the cross-section is to be determined from the following expression:

$\sigma_{\text{c}} = \left(\dfrac{M_{\text{N}}}{Z_{\text{N}}} + \dfrac{M_{\text{p}}}{Z_{\text{p}}}\right)$ x 10^{-3} N/mm^2 ~~(kgf/mm^2)~~

where

M_{N} = ± M_{V} cos φ ± M_{H} sin φ kN m ~~(tonne-f m)~~

M_{p} = ± M_{H} cos φ ± M_{V} sin φ kN m ~~(tonne-f m)~~

M_{V} = ± 0,5 (M_{s} + M_{w}) kN m ~~(tonne-f m)~~

M_{H} = 0,125PL_{h}(2S_{h} − L_{h}) ± M_{L} kN m ~~(tonne-f m)~~

M_{L} = 0,286 f_1 L^2 B kN m ~~(0,029 f_1 L^2 B tonne-f m)~~

P = 4,9(ρ(H − H_{s})^2 − 1,025 (T − H_{s})^2) kN m

~~= (0,5(ρ(H − H_{s})^2 − 1,025 (T − H_{s})^2) tonne-f m)~~

17.2.2 The combined stress for dredging conditions where draught T_{m} exceeds T, is not to exceed the permissible combined stress, σ$_{\text{c}}$ obtained from *Pt 4, Ch 12, 17.2 Hull bending strength 17.2.1*.

M_{V} = ± 0,5 (M_{sm} + $M_{\text{w d}}$) kN m ~~(tonne-f m)~~

17.4 Hinge pins

17.4.1 The diameter of the hinge pins is to be determined using the maximum resultant shear force acting on the pin cross-section in conjunction with an average shear stress not exceeding $\frac{62}{k}\ \text{N/mm}^2\ \cancel{\left(\frac{6,3}{k}\ \text{kgf/mm}^2\right)}$

Part 5, Chapter 1
General Requirements for the Design and Construction of Machinery

■ *Section 3*
Operating conditions

3.1 Availability for operation

3.1.1 The design and arrangement are to be such that the machinery can be started and controlled on board ship, without external aid~~, so that the operating conditions can be maintained under all circumstances~~.

Part 5, Chapter 2
Reciprocating Internal Combustion Engines

■ *Section 1*
General requirements

1.1 Approval process

1.1.7 The engine manufacturer is to apply an approach for product assurance that is suitable for, and includes, the engine types to be certified, *see Pt 5, Ch 1, 1.3 Alternative approach for product assurance* and *Pt 1, Ch 2, 5.3 Quality Control System*. Materials and components are to be manufactured in accordance with this approach and the *Rules for the Manufacture, Testing and Certification of Materials, July 2016*, ~~herein after~~ as applicable.

1.2 Submission requirements

1.2.3 In addition to the applicable plans and particulars required by *Pt 6, Ch 1, 1.2 Documentation required for design review* the following information for control, alarm, monitoring and safety systems relating to the operation of an electronically controlled engine is to be submitted:
Configuration records are to be maintained and are to be made available to the Surveyor at testing and trials and on request in accordance ~~with~~*~~Pt 6, Ch 1, 1.1 General 1.1.4~~* with *Pt 6, Ch 1, 1.1 General 1.1.4* and *Pt 6, Ch 1, 7.1 General 7.1.3*.

~~1.2.7~~ 1.2.6 The following information is to be submitted to LR for acceptance of oil mist detection equipment and alarm arrangements:

~~1.2.8~~ 1.2.7 Where engine components are subject to autofrettage, the following information is to be submitted (*see also Pt 5, Ch 2, 2.5 Autofrettage*):

~~1.2.6~~ 1.2.8 Where considered necessary Lloyd's Register (hereinafter referred to as 'LR') may require additional documentation to be submitted.

■ *Section 2*
Materials and components

2.2 Test and inspections

2.2.1 Except where *~~Pt 5, Ch 2, 2.2 Test and inspections 2.2.1~~* *Pt 5, Ch 2, 2.2 Test and inspections 2.2.2* applies, materials and components for engines are to be manufactured and tested in accordance with the relevant requirements of the *Rules for the Manufacture, Testing and Certification of Materials, July 2016* and *Table 2.2.1 Summary of documentation and testing for engine components*.

■ *Section 7*
Control and monitoring of main, auxiliary and emergency engines

7.3 Auxiliary engine govenors

7.3.2 If an engine cannot achieve the requirements of *Pt 5, Ch 2, 7.3 Auxiliary engine governors 7.3.1* then the actual load step is to be declared and verified through testing to ensure the requirements specified in ~~*Pt 6, Ch 2, 1.7 Design and construction*~~ *Pt 6, Ch 2, 1.8 Quality of power supplies* are satisfied.

■ *Section 12*
Turbochargers

12.2 Works testing and inspection

12.2.1 LR Surveyors are to be provided with free access to the manufacturer’s works to inspect at random the quality control measures and to witness the tests required by ~~*Pt 5, Ch 2, 12.2 Works testing and inspection 12.2.2*~~ *Pt 5, Ch 2, 12.2 Works testing and inspection 12.2.3* to ~~*Pt 5, Ch 2, 12.2 Works testing and inspection 12.2.4*~~ *Pt 5, Ch 2, 12.2 Works testing and inspection 12.2.7* as deemed necessary, and to have free access to all control records and subcontractor’s certificates.

12.2.2 Each individual unit is to be tested in accordance with ~~*Pt 5, Ch 2, 12.2 Works testing and inspection 12.2.2*~~ *Pt 5, Ch 2, 12.2 Works testing and inspection 12.2.3* to ~~*Pt 5, Ch 2, 12.2 Works testing and inspection 12.2.4*~~ *Pt 5, Ch 2, 12.2 Works testing and inspection 12.2.7*.

■ *Section 13*
Air compressors

13.3 Materials

13.3.1 The specified minimum tensile strength of castings and forgings for compressor crankshafts are to be within the limits given in ~~*Pt 7, Ch 14 Requirements for Machinery and Engineering Systems of Unconventional Design*~~ *Pt 5, Ch 2, 2.1 Crankshaft materials 2.1.1* and for grey cast iron to be not less than 300 N/mm^2.

Part 5, Chapter 12
Piping Design Requirements

■ *Section 5*
~~Plastics~~ Plastic piping

5.1 General

5.1.1 Proposals to use ~~plastics~~ plastic pipes in shipboard piping systems will be considered in relation to the properties of the materials, the operating conditions, the intended service and location. Details are to be submitted for approval. Special consideration will be given to any proposed service for ~~plastics~~ plastic pipes not mentioned in these Rules.

5.1.3 ~~Plastics~~ Plastic pipes and fittings will, in general, be accepted in Class III piping systems. Proposals for the use of plastics in Class I and Class II piping systems will be specially considered.

5.1.6 The use of ~~plastics~~ plastic pipes may be restricted by statutory requirements of the National Authority of the country in which the ship is to be registered.

5.2 Design and performance criteria

5.2.4 ~~Plastics~~ Plastic piping, connections and fittings are to be electrically conductive when:

5.3 Design strength

5.3.5 High temperature limits and pressure reductions relative to nominal pressures are to be according to a recognised standard, but in each case the maximum working temperature is to be at least 20^{o}C lower than the minimum temperature of deflection under load of the resin or plastics material without reinforcement. The minimum heat distortion temperature is not to be less than 80°C, *see also Ch 14, 4 ~~Plastics~~ Plastic pipes and fittings* of the Rules for Materials.

5.3.6 Where it is proposed to use ~~plastics~~ plastic piping in low temperature services, design strength testing is to be made at a temperature 10°C lower than the minimum working temperature.

5.4 Fire performance criteria

5.4.1 Where ~~plastics~~ plastic pipes are used in systems essential to the safe operation of the ship, or for containing combustible liquids or sea-water where leakage or failure could result in fire or in the flooding of watertight compartments, the pipes and fittings are to be of a type which have been fire endurance tested in accordance with the requirements of *Table 12.5.3 Fire endurance requirements*.

5.6 Manufacture and quality control

5.6.1 All materials for ~~plastics~~ plastic pipes and fittings are to be approved by LR, and are in general to be tested in accordance with *Ch 14, 4 ~~Plastics~~ plastic pipes and fittings* of the Rules for Materials. For pipes and fittings not employing hand lay up techniques, the hydrostatic pressure test required by *Ch 14, 4.9 Hydraulic test* of the Rules for Materials may be replaced by testing carried out in accordance with the requirements stipulated in a National or International Standard, consistent with the intended use for which the pipe or fittings are manufactured, provided there is an effective quality system in place complying with the requirements of *Ch 14, 4.4 Quality assurance* of the Rules for Materials and the testing is completed to the satisfaction of the LR Surveyor.

5.6.3 ~~Plastics~~ Plastic pipes and fittings are to be manufactured at a works approved by LR in accordance with agreed quality control procedures which shall be capable of detecting at any stage (e.g. incoming material, production, finished article, etc.) deviations in the material, product or process.

5.6.4 ~~Plastics~~ Plastic pipes are to be manufactured and tested in accordance with *Ch 14, 4 ~~Plastics~~ Plastic pipes and fittings* of the Rules for Materials. For Class III piping systems the pipe manufacturer's test certificate may be accepted in lieu of an LR Certificate and is to be provided for each consignment of pipe.

5.7 Installation and construction

5.7.7 The required fire endurance level of the pipe is to be maintained in way of pipe supports, joints and fittings, including those between ~~plastics~~ plastic and metallic pipes.

Part 5, Chapter 13
Ship Piping Systems

■ *Section 2*
Construction and installation

2.1 Materials

2.1.3 Materials sensitive to heat, such as aluminium, lead or plastics, are not to be used in systems essential to the safe operation of the ship, or for containing combustible liquids or sea-water where leakage or failure could result in fire or in the flooding of watertight compartments, *see Pt 5, Ch 12 Piping Design Requirements* for ~~plastics~~ plastic pipes.

■ *Section 6*
Pumps on bilge service and their connections

6.1 Number of pumps

6.1.5 For passenger ships, at least three power bilge pumps are to be provided, one of which may be operated from the main engines. Where the bilge pump numeral as derived from ~~*Regulation 35 - Ventilating systems in machinery spaces*~~ *Regulation 35-1 – Bilge pumping arrangements* of Chapter II-1 of the *International Convention for the Safety of Life at Sea, 1974*, and applicable amendments, is 30 or more, one additional independent power pump is to be provided.

6.3 Capacity of pumps

6.3.2 The capacity of each bilge pumping unit or bilge pump is to be not less than required by the following formula:

$$\cancel{Q = \frac{5,75}{10^3} d^2{}_m} \qquad Q = \frac{5,75}{10^3} d_m{}^2$$

■ *Section 12*
Air, overflow and sounding pipes

12.2 Materials

12.2.1 Air, overflow and sounding pipes are to be made of steel or other approved material. For use of ~~plastics~~ plastic pipes of approved type, *see Pt 5, Ch 12 Piping Design Requirements*.

Part 5, Chapter 14
Machinery Piping Systems

■ *Section 4*
Fuel oil pumps, pipes, fittings, tanks, etc.

4.17 Separate fuel oil tanks

4.17.1 Where separate fuel oil tanks are permitted, their construction is to be in accordance with the requirements of *Pt 5, Ch 14, 4.17 Separate fuel oil tanks 4.17.2* to *Pt 5, Ch 14, 4.17 Separate fuel oil tanks 4.17.6*, *see also* ~~SOLAS 1974 as amended Reg.II-2/B4.~~ ~~*2.2.3 Oil fuel tanks*~~ SOLAS as amended Chapter II-2, Part B, Regulation 4.2.2.3.2.

■ *Section 8*
Lubricating oil systems

8.2 Pumps

8.2.2 The standby pump is to be of sufficient capacity to maintain the supply of oil for normal conditions with any one pump out of action. The pump is to be fitted and connected ready for immediate use, except that where the conditions referred to in ~~*Pt 5, Ch 14, 8.2 Pumps 8.2.1*~~ *Pt 5, Ch 14, 8.2 Pumps 8.2.1(c)* apply a complete spare pump may be accepted. In all cases satisfactory lubrication of the engines is to be ensured while starting and manoeuvring.

Part 5, Chapter 19
Steering Arrangements

■ *Section 1*
General

1.6 Rudder, rudder stock, tiller and quadrant

Table 19.1.1 Connection of tiller to stock

Item	Requirements
(4) Bolted tiller and quadrant (this arrangement could be accepted provided the proposed rudder stock diameter in way of tiller does not exceed 350 mm diameter), *see* symbols	Diameter of bolts, $\cancel{\delta_{tb} = \frac{0,60\delta_{su}}{\sqrt{n_{tb}}}\text{ mm}}$ $\delta_{tb} = \frac{0,60\delta_t}{\sqrt{n_{tb}}}\text{ mm}$

Part 5, Chapter 24
Emissions Abatement Plant for Combustion Machinery

■ *Section 7*
Pumping and piping

7.1 General

7.1.1 Pipe work and transfer systems which may carry chemical substances are to meet the requirements of ~~*Pt 5, Ch 12 Piping Design Requirements*, *Pt 5, Ch 12 Piping Design Requirements* and *Pt 5, Ch 12 Piping Design Requirements*~~ Pt 5, Ch 12 Piping *Design Requirements, Pt 5, Ch 13 Ship Piping Systems* and *Pt 5, Ch 14 Machinery Piping systems*, as applicable. Where it is proposed to apply corrosion resistant lining to steel pipe systems then such lining is to be confirmed as being suitable for the application, in accordance with *Pt 5, Ch 24, 4.1 General 4.1.2*. The elasticity of the lining is not to be less than that of the supporting boundary material.

Part 6, Chapter 1
Control Engineering Systems

■ *Section 1*
General requirements

1.1 General

1.1.4 LR will be prepared to give consideration to special cases or to arrangements which are equivalent to the Rules. For unconventional designs, *see also* ~~*Pt 7, Ch 15 Refrigeration Systems and Equipment Serving Provision Stores and Air-Conditioning Installations*~~ *Pt 7, Ch 14 Requirements for Machinery and Engineering Systems of Unconventional Design*.

■ *Section 2*
Essential features for control, alarm and safety systems

2.4 Safety systems, general requirements

2.4.3 For safety systems required by *Pt 6, Ch 1, 2.4 Safety systems, general requirements 2.4.1(a)* and *Pt 6, Ch 1, 2.4 Safety systems, general requirements 2.4.1(b)* complete independence from other control systems is not necessary.

Part 6, Chapter 2
Electrical Engineering

■ *Section 1*
General requirements

1.2 Documentation required for design review

1.2.9 A schedule of electrical equipment for use in explosive gas atmospheres or in the presence of combustible dusts giving details, as appropriate, of:

- (a) type of equipment;
- (b) type of protection, e.g. Ex `d';
- (c) apparatus group, e.g. IIB;
- (d) temperature class, e.g. T3;
- (e) enclosure ingress protection, e.g. IP55;
- (f) certifying authority;
- (g) certificate number;
- (h) location of equipment.

Details may be included on arrangement drawings for the hazardous locations, in place of a separate schedule. Where uncertified equipment is permitted by *Pt 6, Ch 2, 14.2 Selection of equipment for use in explosive gas atmospheres* or *Pt 6, Ch 2, 14.3 Selection of* *equipment for use in the presence of combustible dusts* or the Rules relevant to the specific type of ship, details of other documentation confirming *Pt 6, Ch 2, 1.2 Documentation required for design review 1.2.9(b)* to *Pt 6, Ch 2, 1.2 Documentation required for design review 1.2.9(d)* may be submitted in place of those listed under *Pt 6, Ch 2, 1.2 Documentation required for design review 1.2.9(f)* and *Pt 6, Ch 2, 1.2 Documentation required for design review 1.2.9(g)*.

1.3 Documents required for supporting evidence

1.3.5 Schedule of normal and emergency operating loads on the system estimated for the different operating conditions expected. The following details are to be provided to meet this requirement:

(a) a description of the expected operating profiles (e.g. the number of generating sets connected when manoeuvring at sea, etc.), including that required by Part 5, *Table 2.1.1 Plans and particulars to be submitted*; and

■ *Section 6*
System design – Protection

6.11 Motor circuits

6.11.1 Motors of rating exceeding 0,5 kW and all motors for essential services are to be protected individually against overload and short-circuit. For motors which for essential services are duplicated, the overload protection may be replaced by an overload alarm; arrangements for steering gear motors are to comply with ~~*Pt 6, Ch 2, 14.1 General*~~ *Pt 6, Ch 2, 15.1 Steering gear*.

■ *Section 14*
Electrical equipment for use in explosive gas atmospheres or in the presence of combustible dusts

14.5 Hazardous zones and spaces

14.5.6 The following zones or spaces are regarded as hazardous, **zone 0**:

(a) the interiors of those spaces, tanks, piping systems and equipment defined by *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.5(a)* and *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.5(b)*; and

(b) enclosed, unventilated spaces containing pipework or equipment defined by *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.5(b)* and *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.5(e)*.

14.5.7 The following zones or spaces are regarded as hazardous, **zone 1**:

(a) unventilated spaces separated by a single bulkhead or deck from a cargo defined by *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.5(a)*;

(b) ventilated spaces containing pipework or equipment defined by *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.5(b)* and *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.5(e)*;

(c) zones within a 1,5 m radius of ventilation outlets, hatches or doorways or other openings into spaces defined by *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.7(a)* or *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.7(b)*, or within 1,5 m of the ventilation outlets of spaces regarded by *Pt 6, Ch 2, 14.7 Ventilation* as open areas and which contain the pipework or equipment defined by *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.5(b)* or *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.5(e)*. Where the hazard results from flammable gas or vapour having a density relative to that of air of more than 0,75, the hazardous zone is considered to extend vertically downward to solid deck, or for a distance of 9 m, whichever is the lesser;

(d) zones on open deck, or semi-enclosed spaces on open deck, within 3 m of the ventilation outlets of cargo tanks defined in *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.5(a)*, which permit the flow of small volumes of vapour or gas mixtures caused by thermal variation;

(e) zones within a 1,5 m radius of flanged joints, or glands or other openings defined by *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.5(b)*; in the case of gas or vapour having a relative density of more than 0,75, the hazardous zone is considered to extend vertically downwards as described under *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.7(c)*;

(f) zones within a 1,5 m radius of flanged joints, or glands or other openings defined by *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.5(e)* and *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.5(f)*;

(g) zones within a 1,5 m radius of bunds or barriers intended to contain spillage of liquids defined by *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.5(a)*;

(h) zones on open deck within a 1,5 m radius of any opening into a space defined by *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.7(a)*;

14.5.8 The following zones or spaces are regarded as hazardous, **zone 2**; and

(b) zones on open deck extending 1,5 m beyond those defined by ~~14.5.7~~~~*Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.7*~~ *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.7(c)*, ~~*Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.7(d),*~~ *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.7(e)*, *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.7(f)*, *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.7(g)* or *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.7(h)*;

(c) zones on open deck extending 2 m beyond those defined by *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.7(d)*;

(d) zones within a 1,5 m radius of ventilation inlets serving spaces defined by *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.7(b)*; and

14.7 Ventilation

14.7.1 Where an enclosed or semi-enclosed space is provided with mechanical ventilation ensuring at least 12 air changes/hour, and leaving no areas of stagnant air, it may be regarded in consideration of hazardous zones as would otherwise be defined by *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.6(b), Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.7(b)* or *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.7(h)* and *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.8(d)*, as an open area.

■ *Section 21*
Testing and Trials

21.2 Trials

21.2.5 Measurements are to be taken as part of the trials specified in *Pt 6, Ch 2, 21.2 Trials 21.2.4(c), Pt 6, Ch 2, 21.2 Trials 21.2.4(d), Pt 6, Ch 2, 21.2 Trials 21.2.4(e)* and *Pt 6, Ch 2, 21.2 Trials 21.2.4(f)* to verify that the installation will provide a quality of power supply in accordance with the values listed in *Pt 6, Ch 2, 1.8 Quality of power supplies*.

■ *Section 23*
Ergonomic Lighting Design – ELD optional notation

23.5 Location of lighting controls and outlets

23.5.1 In order to allow convenient use of lighting the requirements of *Pt 6, Ch 2, 23.5 Location of lighting controls and outlets 23.5.2* to ~~*Pt 6, Ch 2, 23.5 Location of lighting controls and outlets 23.5.2*~~ *Pt 6, Ch 2, 23.5 Location of lighting controls and outlets 23.5.6* are to be complied with.

Part 6, Chapter 3
Refrigerated Cargo Installations

■ *Section 4*
Refrigeration plant, pipes, valves and fittings

4.11 Piping systems

4.11.7 Where the use of ~~plastics~~ plastic pipe is proposed in a secondary refrigerant system (e.g. brine), it is to be in accordance with *Pt 5, Ch 12, 5* ~~*Plastics*~~ *Plastic pipes*.

■ *Section 11*
Acceptance trails

11.5 Reporting of tests

11.5.2 At the end of the first loaded voyage a copy of the logs and temperature records requested in *Pt 6, Ch 3, 11.4 Sea trials 11.4.1(a)* and *Pt 6, Ch 3, 11.4 Sea trials 11.4.1(b)*, as applicable, signed by the ship's Chief Engineer, are to be submitted to LR.

Part 7, Chapter 11
Arrangements and Equipment for Environmental Protection (ECO Class Notation)

■ *Section 1*
General requirements

1.2 ECO class notation: minimum requirements and additional characters

1.2.2 *Pt 7, Ch 11, 3 Supplementary characters* contains additional requirements. Ships complying with these requirements will be eligible for one or more of the following associated supplementary characters, as applicable:
~~**MRV** Monitoring, Reporting and Verification of CO2 emissions.~~

1.5 Information to be submitted

1.5.5 Information and plans:
~~(aa) MRV Plan in accordance with EU regulation 2015/57 (supplementary character **MRV** only).~~
~~(ab)~~ (aa) Underwater noise mitigation strategy, including design and operational considerations (supplementary character **NOISE** only).
~~(ac)~~ (ab) LR Statement of SEEMP conformance and associated documentation (supplementary character **SEEMP** only).
~~(ad)~~ (ac) Any information relating to the environmental performance of the ship, which may influence the assignment of the **ECO** notation.

■ *Section 3*
Supplementary characters

~~3.14 Monitoring, Reporting, Verification – MRV character~~

~~3.14.1 For assignment of the MRV character, CO^2 emissions are to be monitored, reported and verified, in accordance with the EU Regulation 2015/757.~~

~~3.14.2 The MRV Plan is to be reviewed and CO^2 emissions independently verified by LR.~~

~~3.15~~ 3.14 Underwater noise from commercial shipping – NOISE character

~~3.15.1~~ 3.14.1 For assignment of the NOISE character, compliance with *MEPC.1/Circular.833 – Guidelines for the Reduction Of Underwater Noise From Commercial Shipping to Address Adverse Impacts on Marine Life – (07 April 2014)* is to be demonstrated.

~~3.15.2~~ 3.14.2 In order to demonstrate compliance with *MEPC.1/Circular.833 – Guidelines for the Reduction Of Underwater Noise From Commercial Shipping to Address Adverse Impacts on Marine Life – (07 April 2014)*, an underwater noise mitigation strategy is to be prepared, which should consider all primary sources of underwater noise, associated with propellers, hull form, on board machinery and operational conditions which may affect underwater noise. These are to be in accordance with paragraphs 7, 8, 9 and 10 of *MEPC.1/Circular.833 – Guidelines for the Reduction Of Underwater Noise From Commercial Shipping to Address Adverse Impacts on Marine Life – (07 April 2014)*.

~~3.15.3~~ 3.14.3 Underwater noise shall be measured, as far as practicable, in accordance with paragraph 6 of *MEPC.1/Circular.833 – Guidelines for the Reduction Of Underwater Noise From Commercial Shipping to Address Adverse Impacts on Marine Life – (07 April 2014)*. Where it is not practicable, alternative proposals will be considered.

~~3.16~~ 3.15 Refrigeration systems – R character

~~3.16.1~~ 3.15.1 For assignment of the **R** character, natural substances are to be used as the refrigerants in all main refrigeration systems such as cargo systems, provision rooms and air conditioning.

~~3.16.2~~ 3.15.2 Small factory-built refrigeration system(s) that use fluorinated refrigerants, having a Global Warming Potential (GWP) of less than 1950 are allowable.

~~3.16.3~~ 3.15.3 The GWP value is based on the 100-year time horizon.

~~3.17~~ 3.16 Sulphur oxides – DIST and SOx characters

~~3.17.1~~ 3.16.1 For assignment of the **DIST** character, ships must meet the requirements of LR's Descriptive Note **DIST(M, AB, I, IG)**, as applicable.

~~3.17.2~~ 3.16.2 For assignment of the **SOx** character, all fuel used on board is to be:
(a) distillate with a sulphur content not exceeding 0,10 per cent m/m; or
(b) an alternative fuel or a hybrid fuel management solution which has a resulting sulphur content which is not to exceed 0,10 per cent m/m.

~~3.17.3~~ 3.16.3 The sampling, fuel sulphur analysis methods and verification requirements stipulated in *Pt 7, Ch 11, 2.3 Sulphur oxides (SOx) 2.3.4* and *Pt 7, Ch 11, 2.3 Sulphur oxides (SOx) 2.3.5* are to be complied with.

~~3.17.4~~ 3.16.4 Alternative arrangements providing an equivalent level of environmental protection will be considered for the assignment of the **SOx** character. If an Exhaust Gas Cleaning System is fitted, it is to be certified to *Resolution MEPC.184(59) – 2009 Guidelines for Exhaust Gas Cleaning Systems – (adopted on 17 July 2009)*.

~~3.18~~ 3.17 Enhanced tank cleaning – TC character

~~3.18.1~~ 3.17.1 For the assignment of the **TC** character, oil and chemical tankers are to be provided with tank washing equipment meeting the standards specified in *Pt 7, Ch 11, 3.18 Enhanced tank cleaning – TC character 3.18.2* to *Pt 7, Ch 11, 3.18 Enhanced tank cleaning – TC character 3.18.8*.

~~3.18.2~~ 3.17.2 Cargo tanks are to be served by individual pumps.

~~3.18.3~~ 3.17.3 Permanent tank washing machines shall be type approved in accordance with the revised *IMO Resolution A.446(XI) – Revised specifications for the design, operation and control of crude oil washing systems – (Adopted on 15 November 1979)*, and their method of support is to be acceptable to LR.

~~3.18.4~~ 3.17.4 At the design stage the following minimum procedures are to be used to determine the area of the tank surface covered by direct impingement (longitudinals, brackets, stiffeners, ladders, pipework, corrugations on corrugated bulkheads and face plates can be ignored):
(a) using suitable structural plans, lines are set out from the tips of each machine to those parts of the tank within the range of the jets; or
(b) a pinpoint of light simulating the tip of the tank washing machine in a scale model of the tank are to be used.
Alternative methods of measurement will be considered.

~~3.18.5~~ 3.17.5 Additional tank washing equipment, which may be portable, is also to be provided to enable washing of the shadow areas without the necessity to enter the tanks. The use of portable machines to wash the shadow areas is not to be undertaken where the last cargo in the tank has toxic or low ignition properties, reacts with water or has other properties specified in chapter 15 of the *IBC Code - International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk Amended by Resolution MEPC.225(64)* which would prevent water washing or opening of the tank to allow the use of portable washing machines.

~~3.18.6~~ 3.17.6 A back-up system to provide cleaning capability in the event of failure of one tank washing machine is to be provided.

~~3.18.7~~ 3.17.7 Heating equipment is to be provided for a tank washing medium which achieves a minimum temperature of 85°C at the connection to the tank washing machine.

~~3.18.8~~ 3.17.8 The effectiveness of the tank washing system is to be confirmed by tank inspections or other means as required by LR. The confirmation is to be carried out when the ship is in service. For ships fitted with crude oil washing system(s) the confirmation will be carried out as part of the MARPOL *Annex I of MARPOL 73/78Regulations for the Prevention of Pollution by Oil* survey and need not be carried out separately.

~~3.19~~ 3.18 Vapour emission control systems – VECS-L, VOC-R characters

~~3.19.1~~ 3.18.1 Tankers carrying crude oil, petroleum products or chemicals having a flash point not exceeding 60°C (closed-cup test) will be assigned the **VECS-L**, **VOC-R** character(s) provided the requirements of *Pt 7, Ch 11, 3.19 Vapour emission control systems – VECS-L, VOC-R characters 3.19.2* and/or *Pt 7, Ch 11, 3.19 Vapour emission control systems – VECS-L, VOC-R characters 3.19.3* respectively are complied with, as applicable.

~~3.19.2~~ 3.18.2 For assignment of the **VECS-L** character, a vapour emission control system is to be fitted, as specified in *Pt 1, Ch 2, 2.8 Descriptive notes*, and designed and constructed to meet the requirements for vapour balancing in accordance with USCG 46, CFR 39.40 for service vessels.

~~3.19.3~~ 3.18.3 For assignment of the **VOC-R** character, a self-contained system capable of preventing vapour emission formation during loading is to be fitted. This vapour emission prevention system is to be of a type approved by LR and is to reduce vapour emission formation by at least 75 per cent (v/v) as compared to an equivalent ship to which no vapour emissions prevention system has been fitted.

Part 7, Chapter 12
Passenger and Crew Accommodation ~~comfort~~ Comfort

■ *Section 1*
General requirements

1.3 Class notations

1.3.2 The **PAC** (Passenger Accommodation Comfort), **CAC** (Crew Accommodation Comfort) and **PCAC** (Passenger and Crew Accommodation Comfort) notations are optional and are primarily intended to apply to passenger ~~ship's~~ ships. If requested, however, any ship can be assessed for compliance, using these requirements as the basis for the assessment and ~~a~~ an LR Certificate of Compliance issued (*see Pt 7, Ch 12, 1.1 Scope 1.1.3* ~~and*Pt 7, Ch 12, 1.4 Certificate of Compliance*~~ and *Pt 7, Ch 12, 1.4 Certificate of Compliance*).

Part 8, Chapter 2
Ice Operations – Ice Class

■ *Section 12*
Requirements for Icebreaker(+)

12.7 Propulsion and machinery arrangements

12.7.2 The propulsion power, at 2 knots, for icebreakers may be expressed as follows, where the ice thickness and icebreaker breadth form the dominant role:

~~$P = 100B^{0,7}h \left(1,4 - \frac{2h}{B}\right)$ kW~~ $P = 100B^{0,7}h \left(1,4 - \frac{2h}{B}\right)$ kW

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